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Management of coastal lagoon fisheries and aquaculture in Italy

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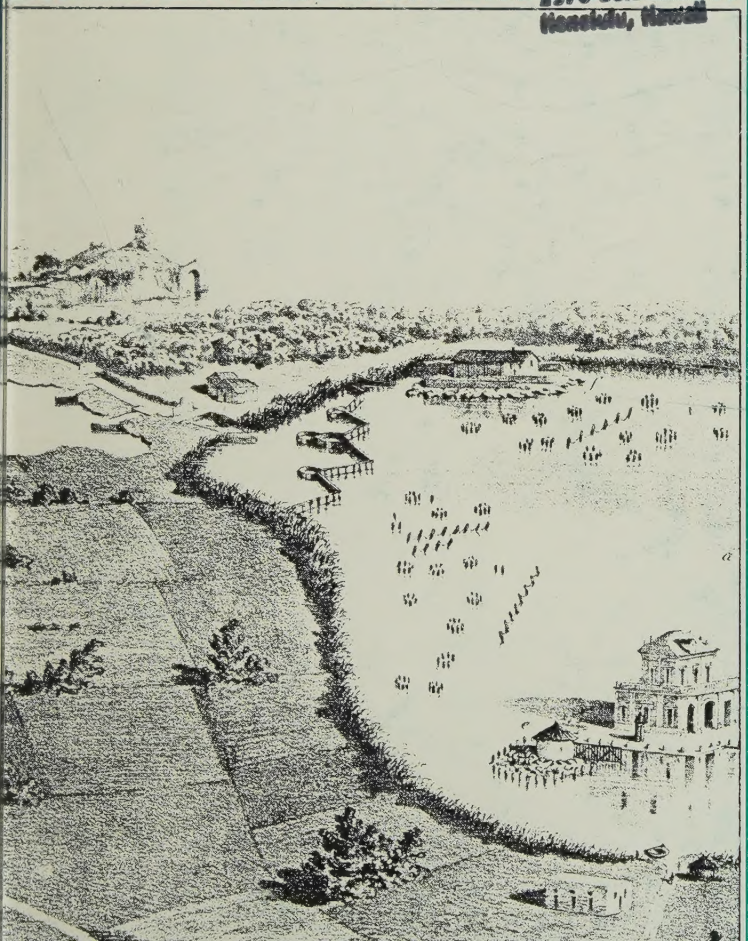

FAO
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PAPER

293

FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

Management of coastal lagoon fisheries and aquaculture in Italy

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Rome, 1988

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PREPARATION OF THIS DOCUMENT

This is one of a series of Technical Papers on the management of coastal lagoons for fisheries and aquaculture. The Technical Papers are a follow-up to the FAO Expert Consultation on the Management of Coastal Lagoon Fisheries (Rome, September 1983; papers published in FAO General Fisheries Council for the Mediterranean Studies and Reviews No. 61, Vols. 1 and 2, 1984). Other Technical Papers in the present series on bordigues, and hydrological management of lagoons for fisheries and aquaculture, are under preparation.

Comments are welcome, and should be directed to the Chief, Inland Water Resources and Aquaculture Service, FIRI, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

The illustration on the cover is part of a lithograph taken from Coste (1855) which represents Fusaro lagoon in the first half of 1800.

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ABSTRACT

This is a report prepared for biologists, managers and administrators of fisheries in developing countries. It is a synthesis of many centuries of coastal lagoon management in Italy. Many of the management solutions may be applicable elsewhere.

The report includes an inventory and characterization of the Italian coastal lagoons, their environmental characteristics, exploited species, fishing gears, kinds of management and yields obtained, and administrative, economic and research considerations. Lagoon fisheries are discussed in the context of coastal zone management and in relation to the development of aquaculture. In addition, there are seven case studies which provide a range of lagoon fishery management problems and solutions.

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1. INTRODUCTION

1.1 Objectives

This paper has been written for fishery biologists, managers and administrators of developing countries.

Italian management of lagoon environments started long ago and shows models that offer a reference point for other geographical areas, particularly in the Mediterranean region. Besides traditional activities, in the last twenty years Italian lagoon environments have been affected by the developments of new aquaculture technologies. This makes it possible to analyse the advantages and the limits of such a development trend since, as far as the Italian experience is concerned, traditional management experiences have turned out to be able to integrate or even clash with new ones.

Moreover, it is now clear that socio-cultural and socio-economic aspects predominate in these complex systems, besides the biotechnological aspects. Thus, in planning lagoon management, one must now consider such elements as: a modified concept of the utilization of coastal areas, considered as an important environmental asset, as well; changed environmental conditions (pollution); new socio-economic necessities of the personnel engaged in resource management.

As far as the biotechnological aspects to increase the yield of lagoon environments are concerned, intensive aquaculture plants was to be the solution to the microeconomic problems of the undertaking and have positive consequences also in macroeconomics. But experience has shown that such a model is affected by the same problems as traditional lagoon management, i.e. quality of the environment, and requires big quantities of fry. This shows that technological innovations must match traditional methods and that they prove to be valid only when traditional ones are still vital for economics.

The Italian model is a good reference for the development of policies, that must not be traumatic either for the human communities involved in the exploitation and in the management of lagoon resources or for the environment.

The authors have tried to synthetize the complex reality of italian coastal lagoon management to enable a biologist, manager or administrator to determine whether

these experiences can be adapted to his own management needs.

1.2 Definitions

It is estimated that the coastal lagoon environments that can be utilized for fisheries and aquaculture in Italy cover around 150,000 hectares (Colombo, 1981). Approximately 61,000 ha (Laboratorio Centrale di Idrobiologia, 1983) are presently exploited: these areas are located mostly in the Upper Adriatic (around 30,000 ha), in the Po Delta (around 12,000 ha) and the rest in Apulia, Campania, Latium, Tuscany, Sicily and Sardinia (Fig. 1).

Coastal lagoons are bodies of salt water (from brackish to hypersaline) partially separated from an adjacent sea by barriers of sand or other sediment, with openings through which seawater can flow. Within this category confusion of terms can arise: coastal lagoon may not always have the same meaning for a biologist and a geologist, in the same way as French étang can be a lagoon for the Italians or a coastal lake for the Anglo-Saxons.

These water bodies along the Italian coasts show various origins, geo-morphological features, water and fishing management and, finally, are named differently.

In Italy, the term "lagoon" is used only for the large brackish areas of the North Adriatic (Venice, Grado and Marano) and for the lagoon of Orbetello (Tuscany). The coastal basins of the North Adriatic are called Valli; most other coastal basins of the peninsula are called "lakes", while the term "pond" (stagno) is currently used in Sardinia, recalling more closely the origins of the French equivalent étang.

The term valle (deriving from the Latin vallum meaning embankment) was originally the simple and primitive lagoon sector enclosed for fish-culture purposes. From valle we have vallicultura which is a term generally, but incorrectly, used to indicate all forms of lagoon aquaculture.

Vallicultura is one of the most ancient forms of aquaculture: its origins date back to the first rudimental fish ponding and fattening systems used along the Adriatic and Tyrrhenian coasts. This technique was developed by the upper Adriatic populations to exploit the seasonal migrations of some fish species from the sea into the

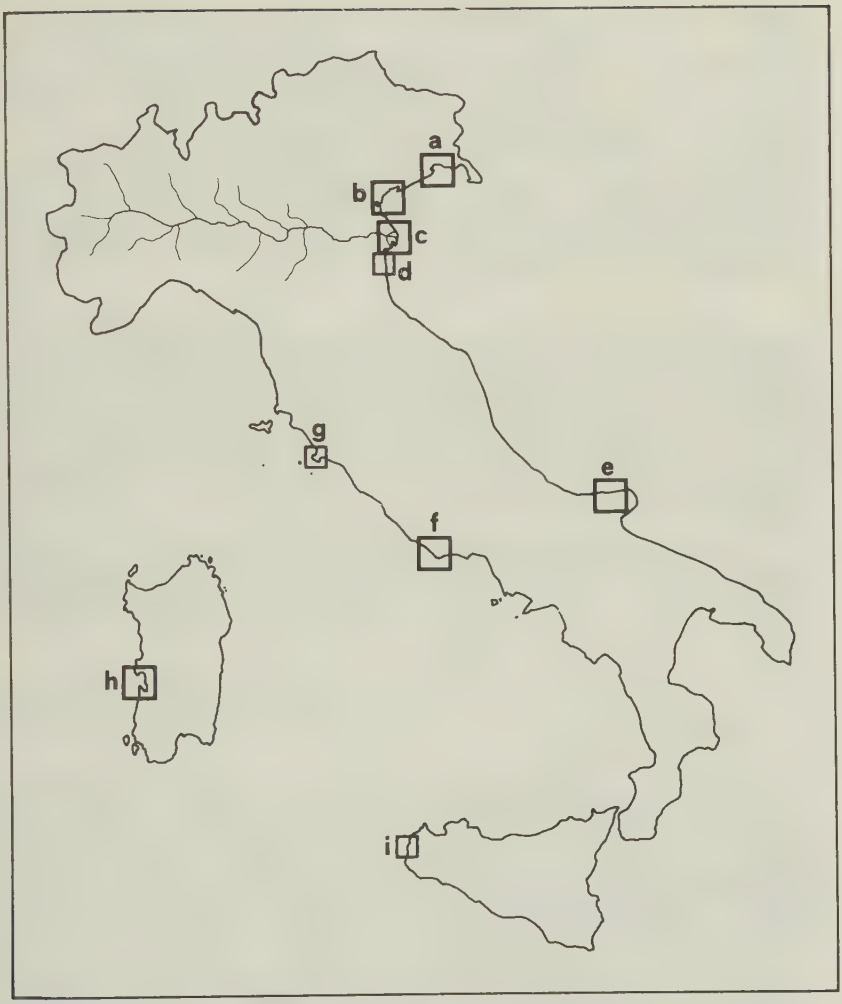

Figure 1. The main areas of coastal lagoons in Italy: a) lagoon of Grado and Marano; b) lagoon of Venice; c) Delta of Po river; d) Valli of Comacchio; e) lagoons of Lesina and Varano; f) Pontine coastal lagoons; g) lagoon of Orbetello; h) lagoon of Cabras; i) lagoon of Marsala (see Figs. 2 - 10).

lagoon and delta areas which are more suitable for their growth. They return to the sea because of altered environmental conditions (temperature) to the sea or for reproduction. To exploit these periodic movements, large brackish areas were enclosed to prevent the fish descent toward the sea and complex permanent capture systems, lavorieri (fish barriers), were developed consisting of barriers in the channels communicating with the sea to catch the adults. Later, from the simple ponding of fry freely immigrated into the lagoon, came a man-made seeding of fry fished elsewhere and introduced into the basins to be reared for a few years.

According to Bullo (1891), the development of vallicultura can be described by the various types of valle enclosures which succeeded one another. At first, there were open valli which were practically unenclosed lagoon sectors with, however, exclusive fishing rights; later these areas were delimited first only with long marsh reed fences (serraglia) then at least partially embanked (semi-arginata), and finally completely with strong and lasting embankments (arginata).

At present, the term "fishing valle" means a lagoon water surface of extremely variable dimensions, surrounded by embankments made from earth or other inert material communicating directly or indirectly with the sea, and in some cases, with fresh waters.

In this paper we shall refer to all Italian brackish water bodies, exept for the valli with the unequivocal term of "coastal lagoon."

In the other Italian coastal lagoons, particular forms of fish management can mostly be found instead of fish culture. Here in fact, a free ascent of eels, grey mullet and other species can be found: fishing occurs inside the basins ("wandering" fishing) and, when present, at the fish barriers but without precise seasonal cycles and all those features which are typical of vallicultura.

Other typical brackish environments are the sacche (bays) of the River Po Delta; these are wide bays communicating with the sea through large mouths only partially enclosed by sand banks. Though presenting many similar features to the coastal lagoons; these basins are exploited by generic fishing activities (Rossi et al., 1984). In some, the only aquaculture activity is the culture of molluscs.

1.3 Historical origins

Italian coastal lagoons reflect the events of two and a half centuries of history.

Historical evidences of active management of coastal lagoons can be dated back to the V - IV century B.C. and the Etruscans. At that time in the middle Tyrrhenian sea, the Etruscan town of Cosa was located on a small hill of the south coast of Orbetello lagoon. Important works of hydraulic management by cutting hundreds of metres of the shoreline rocks (tagliata di Ansedonia) can be linked to this urban settlement.

The origins of these works were probably in the fishing and water exchange needs of a large coastal lagoon (between 500 and 1,000 ha) now reduced up to few hectares (lagoon of Burano). Also in the nearby lagoon of Orbetello the first fishing management was practised by the inhabitants of Cosa (Del Rosso, 1905). During the same centuries in the lagoons of the Po Delta, the Etruscans built the town of Spina, near Comacchio. The detection of a star-like fish barrier endowed with wooden sluice-gates, testify to the capacity of that people to catch fish both incoming from the sea and outgoing from the lagoon (Felletti-Spadazzi, 1987)

Previous evidence comes from the Latium lagoons where, before the Etruscans, prehistoric populations lived in villages on stilts.

The Romans were the first aquaculturists on the Italian shoreline and ruins of fish ponds, mainly for the maintenance of live fish (i.e., the famous murenari), were common along the Latium coast (Scalfati, 1968).

Finally, the most famous Italian coastal lagoon, the Valli of Comacchio, is worth a short mention. In 1500, its fame was linked to its fish barriers and Torquato Tasso praised these gear because they always allowed the entry and never the exit (che' quel serraglio e` con mirabil uso, sempre a l'entrar aperto, all'uscir chiuso).

The begining of the recent history of Comacchio valli dates from 1325 when they were bought by the Estensi, princes of Ferrara. The Estensi were deprived of authority by the Papal Kingdom in 1598. From that time until 1797 the valli were managed mainly by local inhabitants through rents. The yearly fish yields of the valli are available from 1781. In 1796 the whole region was conquered by

Napoleon and on 11 July 1797 he gave the valli to the people and town of Comacchio. With the Restoration, Comacchio returned to the Papal Kingdom in 1813. In 1868 the valli were returned to the town of Comacchio. Management was carried out through concessionaires until 1933 when direct management was established.

More historic data will be given in specific sections, for example, for fishing gear and fish barriers.

2. ITALIAN COASTAL LAGOONS

The following is basic information on the main Italian coastal lagoons. This inventory should not be considered exhaustive since it does not include, as a rule, lagoons of small dimensions. The information is taken from various authors but because much of it comes from old surveys, and because very often the owners themselves are uncertain, caution is required. For example there are problems connected with the definition of the actual water surfaces, as many coastal lagoons include large emerging sandbanks, the dimensions of which are difficult to determine. On the other hand, it is on the data of actual exploitable surfaces that all attempts of technico-economic analysis are to be based: production (kg/ha/yr) can be compared with difficulty for environments that might have the same total area but an exploitable surface of 90 % in one case and less than 50 % in the other.

2.1 Adriatic area

2.1.1 Friuli-Venezia-Giulia region

The Friuli-Venezia-Giulia Region brackish areas are mainly located in the lagoons of Grado and Marano (Regione Autonoma Friuli-Venezia-Giulia) between the mouths of the rivers Tagliamento and Isonzo. Their area is 12,717 ha, 2,434 of which are emerged areas; they cover an area measuring approximately 32 km in length and around 5 km in average width (Fig. 2).

In the lagoons of Grado and Marano there is a series of 36 embanked areas over a surface of 1,236 ha. These areas are autonomous units in controlled communication with the rest of the lagoon. The area of a single valle can vary considerably from a few hectares to a maximum of 220 ha.

Table 1. Some *valli* of the lagoons of Grado and Marano (with the water surface in brackets)

1) Valle Franca Mella, 60 ha (40).
2) Valle Noghera, 220 ha (150).
3) Valle Morgo, 80 ha (64).
4) Valle Ravaiarina, 36 ha (25).
5) Valle Gorgo, 70 ha (42).
6) Valle Moro, 15 ha (13).
7) Valle Frate Zuane, 18 ha (13).
8) Valle Ribi, 92 ha (48).
9) Valle Luzzatto, 35 ha (25).
10) Valle Artalina, 125 ha (100).
11) Valle Fossalon, 190 ha (95).

2.1.2 Venezia region

The brackish areas of the Venezia region are:

i) The lagoon of Caorle consists mainly of five *valli* for a total area of 1,700 ha: Valle Zignago (250 ha), Valle Perera (150 ha), Valle S. Gaetano (548 ha), Valle Nuova (475 ha) and Valle Grande (280 ha) (Ravagnan, 1978a) (Fig. 2).

ii) The lagoon of Venice (Pellizzato and Scattolini, 1982) covers an estimated area of 57,769 ha, of which 51,870 ha of water and 5,899 ha of islands, cultivated or built up areas, reclaimed ground and natural silted up areas. It averages 1.5 metres in depth; its salinity varies between 10 and 36 ‰ , according to the distance from the mouths. The whole basin is surrounded by a sandbank along a total length of about 50 km between the mouths of the rivers Brenta and Sile. The *valli* cover a surface of 8,808 ha in the lagoon (Boatto and Signora,1985), the remaining area being used for mussel culture and fishing (Fig. 3).

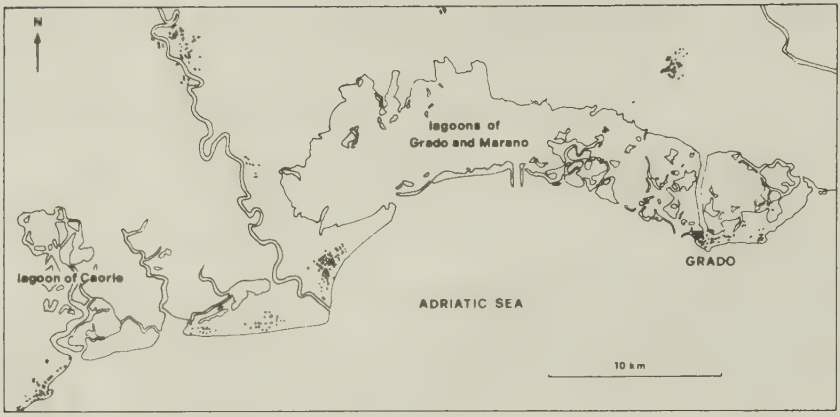

Figure 2. Lagoons of Grado and Marano

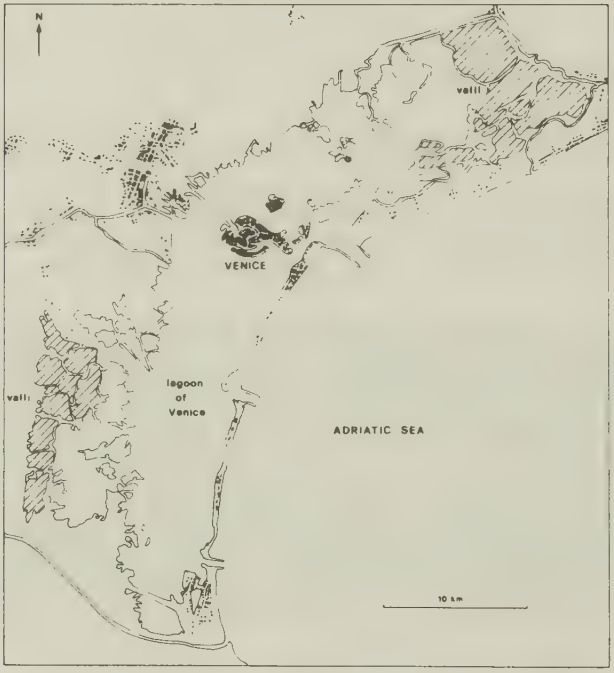

Figure 3. Lagoons of Venice

Table 2. The embanked valli of the lagoon of Venice (Boatto and Signora, 1985) (water surface in brackets)

1) Valle Doga`, 1,650 ha (1,000).
2) Valle Grassabo`, 860 ha (640).
3) Valle Fosse, 174 ha (168).
4) Valle Dragoiesolo, 1,159 ha (900).
5) Valle Cavallino, 358 ha (230).
6) Valle Lio Maggiore Capanno, 86 ha (70).
7) Valle Lio Maggiore La Bianca, 55 ha (50).
8) Valle Falconera 40 ha (31).
9) Valle Sacchetta-Sacchettina, 118 ha (85).
10) Valle Paleazza, 378 ha (227).
11) Valle Olivari, 65 ha (50).
12) Valle Sparesera, 22 ha (18).
13) Valle S. Cristina, 30 ha (11).
14) Valle Ca` Derina o Perini, 310 ha (155).
15) Valle Serraglia, 400 ha (300).
16) Valle Averto, 300 ha (250).
17) Valle Contarina-Tezze, 353 ha (300).
18) Valle Zappa, 380 ha (350).
19) Valle Cornio Basso, 200 ha (170).
20) Valle Cornio Alto, 120 ha (100).
21) Valle Figheri, 433 ha (350).
22) Valle Pierimpie`, 528 ha (400).
23) Valle Ghebbo Storto, 228 ha (140).
24) Valle Morosina, 561 ha (400).

iii) Delta of the Po river: different types of environments can be found according to the physiografic and hydrologic features of the Po Delta. Typical of this area are the sacche: large bays in open comunication with the sea mainly found in the southern part of the delta. (Canarin, Basson, Scardovari, Goro).

The actual fishing valli cover a total area of 8,291 ha (Rinaldi, 1960) (Fig. 4).

Table 3. The valli of the Po Delta (water surface in brackets)

1) Valle Boccavecchia, 330 ha (300).
2) Valle Canelle, 210 ha (136).
3) Valle Passarella, 168 ha (135).

4) Valle Morosina, 310 ha (283).
5) Valle Spolverina, 266 ha (229).
6) Valle Sega`, 578 ha (524).
7) Valle Capitania, 231 ha (194).
8) Vallesina, 54 ha (50).
9) Valle Veniera, 238 ha (205).
10) Valle Sagreda, 355 ha (273).
11) Valle Pozzattini Vecchi, 237 ha (195).
12) Valle Pozzattini Nuovi, 62 ha (32).
13) Valle Canocchione-Moraro, 756 ha (602).
14) Valle Sacchetta, 607 ha (502).
15) Valle Lisetto (Bagliona), 551 ha (501).
16) Laguna Vallona, 886 ha (740).
17) Valle Ca` Pasta, 213 ha (162).
18) Valle Ca` Pisani, 732 ha (539).
19) Valle S. Leonardo, 375 ha (313).
20) Valle Scannarello, 292 ha (230).
21) Valle Ripiego, 334 ha (255).
22) Valle S. Carlo, 506 ha (501).

2.1.3 Emilia Romagna Region

The two main lagoon complexes in Emilia Romagna are Valle Nuova and the Valli of Comacchio. The name of Valle Nuova covers a complex of valli (Valle Cantone, Valle Bertuzzi, Valle Nuova) for a total surface of 1,890 ha. It averages 50 cm in depth and the average salinity has been increasing from 5-6 ‰ in 1967 to 17-22‰ at present (Rossi and Papas, 1979).

The Valli of Comacchio (Fig. 5) include three lagoons connected to the sea by three canals: Valle Campo (1,638 ha, average depth 0.93 m) is the closest to the sea; Valle Fossa di Porto (2,890 ha, average depth 1.11 m) is the most distant from the sea; Valle Lido di Magnavacca (6,098 ha, average depth 1.09 m) is the largest.

The Valli of Comacchio as seen today are the remains of an impressive lagoon complex of approximately 49,000 ha which land reclamation works brought down to the present 10,000 ha (Cognetti et al. 1975). Another lagoon used for rearing is Valle Furlana (1,951 ha), including also Val Bru (700 ha), Valle Smarlacca (190 ha), Valle Ussarola (180 ha) and Valle S. Clemente di Primaro (180 ha).

Figure 4. Delta of Po River valli

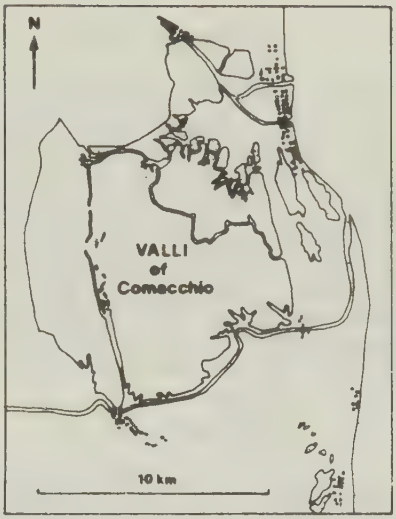

Figure 5. Valli of Comacchio

2.1.4 Apulia region

Apulia is the region with the largest coastal lagoons in southern Italy: Lesina and Varano (Fig. 6). These are situated north of the Gargano promontory. In the remaining southern part of the region, instead, we find numerous small lagoons and marsh areas. The lagoon of Lesina covers an area of 5,100 ha and its depth averages 0.6 m, reaching a maximum of 1.5 m. Varano covers an area of 6,100 ha with a maximum depth of 6 m in the central parts (De Angelis R., 1963, 1964; Lumare, 1987). Among the other lagoons we can mention the lagoon of Aquatina (40 ha) and the Alimini lagoons (256 ha).

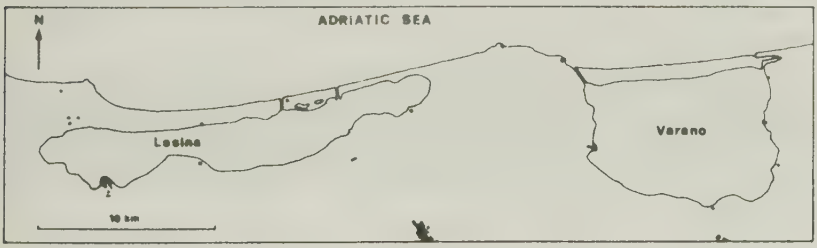

Figure 6. Lagoons of Lesina and Varano

2.2 Tyrrhenian area

2.2.1 Campania region

The Campania region has medium-small coastal lagoons. The largest is the Patria lagoon with approximately 200 ha and an average depth of 1.3 m (max. 1.5 m). It has only one mouth to the sea and its salinity varies generally between 9 and 13‰ . The lagoon of Fusaro has an area of 97 ha, and an average depth of 3 m (max. 6 m); it is surrounded by quays, and it is connected to the sea through three mouths; its salinity averages 36‰ . The lagoon of Miseno has an area of 40 ha, an average depth of 2 m (max. 4 m) and it is surrounded by quays. It is connected to the sea through two mouths and its salinity varies between 35 and 37‰ .

2.2.2 Latium region

The Latium region includes six lagoons for a total of 1,640 ha (Fig. 7): the first four are in the remains of the Pontine marshes and the other two in the Fondi marshes (Della Valle, 1961; Ardizzone, 1985).

i) Fogliano: covers 404 ha and averages 1 m in depth. It has three mouths, two of which are connected with freshwater canals and one with the sea. Its salinity varies between 28 and 48‰ .

ii) Monaci: area 95 ha, average depth 1 m and salinity between 17.3 and 38‰ . It has only one mouth opening out on a canal which conditions its sub-dystrophic state and which requires pumping in outside waters to improve its water exchange.

iii) Caprolace: area 226 ha, average depth 1.3 m (max. 2.9 m). It has two mouths opening out to the sea. Salinity varying between 32.6 and 44‰ .

iv) Sabaudia: has an area of 375 ha and averages 4.5 m in depth (max. 10 m). Its salinity ranges between 25 and 35‰ . It is connected with the sea through two mouths. Its considerable depth creates local stratification conditions and anoxia on the bottom.

v) Fondi: it has an area of 381 ha and averages 9 m in depth (max. 21 m). This considerable depth causes an ever stratified state of the waters and anoxia at the bottom. Its salinity varies between 3 and 13‰ on the surface and between 10 and 22‰ at 10 meters. It is connected to the sea by two long canals.

vi) Lungo: is the smallest of the coastal lakes in Latium (47 ha). It averages 4.5 m in depth (max. 7 m) and it communicates with the sea through one mouth.

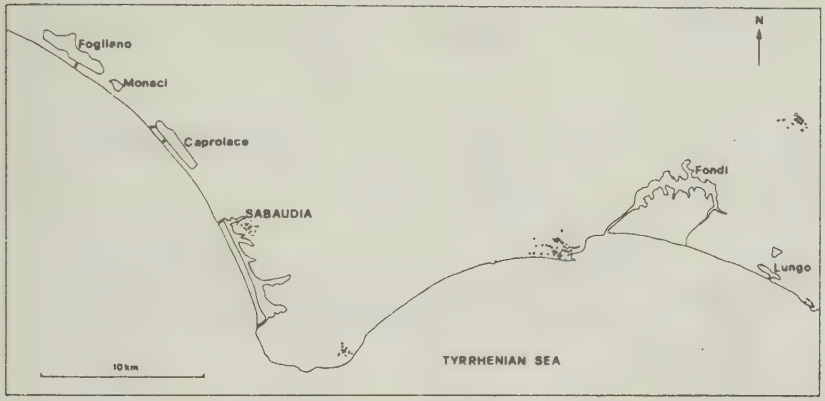

Figure 7. Lagoons of Latium region

2.2.3 Tuscany region

The Tuscany coastal lagoons are:

i) Orbetello (2,700 ha) is the largest Tyrrhenian lagoon (Fig. 8). It is divided in two areas, Ponente (west) (,1500 ha) and Levante (east) (1,200 ha). It averages 1 m in depth. The Ponente sector is connected with the sea through two canals whereas the Levante sector has only one mouth. Salinity varies between 27.7 and 47.4‰ (Regione Toscana, 1978).

ii) Burano (140 ha, 100 water surface): is connected to the sea through a mouth which periodically silts. Salinity varies between 10 and 26‰. It averages 80 cm in depth, but it tends to silt up rapidly at the two ends (Cognetti et al., 1978; Ardizzone et al., 1982).

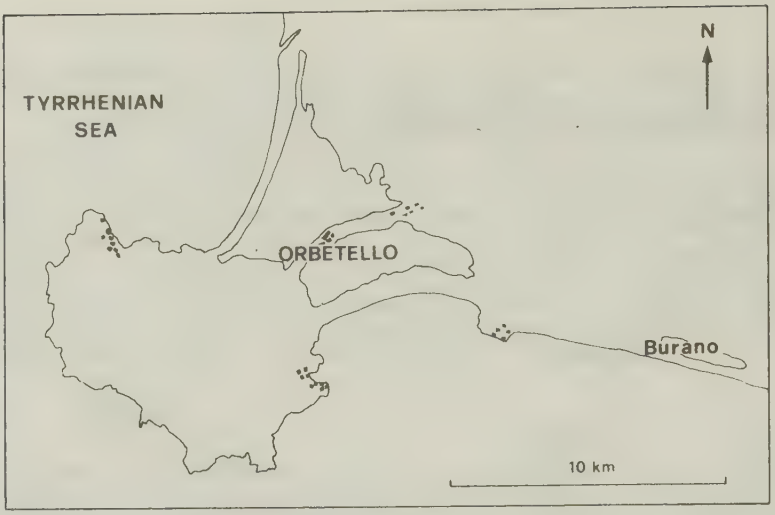

Figure 8. Lagoon of Orbetello

2.3 Sardinian area

Sardinia is the Italian region with the largest number of coastal lagoons. These basins number over a hundred and, although most of them are small, they have an overall area of around 10,000 ha (Cottiglia, 1981). The centre-west coastline is the richest in lagoons (Fig. 9).

The environmental and the fishing resource management are extremely variable. In general, the lagoons are not very deep (less than 1 m) and salinity varies from oligomesohaline conditions as, for example, San Giovanni or Santa Giusta, to hyperhaline conditions as in the ponds of San Teodoro, Colustrai and Porto Pino.

Table 4. The main coastal lagoons in Sardinia (clockwise from south)

---

1) Stagno di Santa Gilla, 1,497 ha
2) Stagno di Porto Pino, 441 ha
3) Stagno di San Giovanni, 200 ha
4) Stagno di Marceddi`, 800 ha
5) Stagno di Corru de S'Ittiri, 180 ha
6) Stagno di S'Ena Arrubia, 215 ha
7) Stagno di Santa Giusta, 800 ha
8) Stagno di Cabras, 2,200 ha
9) Stagno di Mistras, 250 ha
10) Stagno di Is Benas, 124 ha
11) Stagno di Sale Porcus, 324 ha
12) Stagno di Calich, 97 ha
13) Stagno di Casaraccio, 122 ha

14) Stagno di Porto Pozzo, 220 ha
15) Stagno di San Teodoro, 214 ha
16) Stagno di Sa Curcurica, 40 ha
17) Stagno di Tortoli`, 289 ha
18) Stagno di San Giovanni, 150 ha
19) Stagno di Colustrai, 95 ha

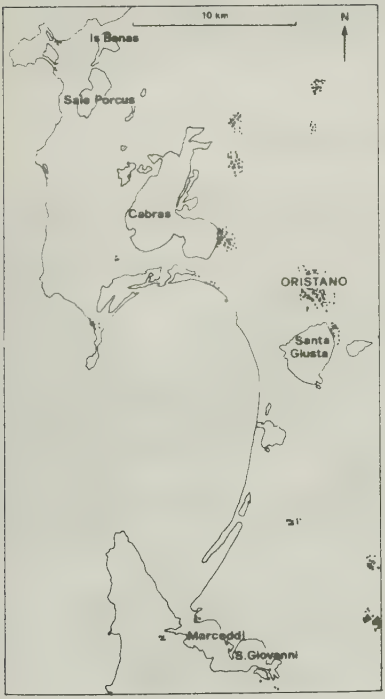

Figure 9. The main lagoons of western Sardinia

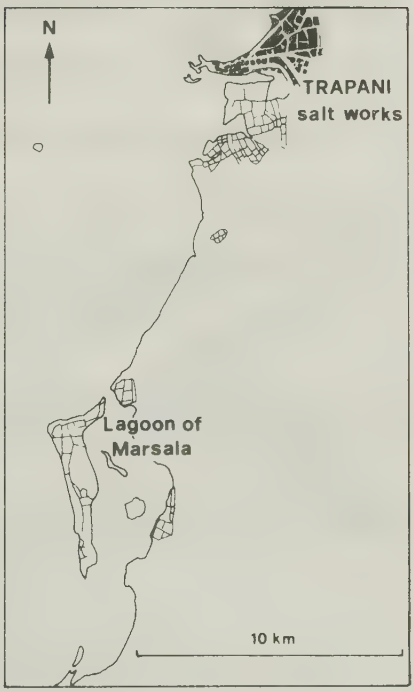

Figure 10. Lagoon of Marsala

2.4 Sicilian area

Sicily is rather poor in lagoons (Faranda, 1977). The most interesting part is the western tip of the island with the saltworks of Trapani and the Stagnone of Marsala (Fig. 10). The saltworks complex, with a total of 480 ha of mainly rectangular pools, was originally intended for sea salt collecting and was used for aquaculture only as a side activity. Recently aquaculture activities are developed in these areas.

The Stagnone, more than an actual lagoon, is a section of open sea only partially enclosed by an island and submerged sandbanks (Cavallaro et al., 1978; Riggio et al., 1983).

The swamp areas in the south of Sicily (Longarini, 105 ha, Vendicari, 108 ha) must also be mentioned. They are so called because their water content is neither constant nor permanent, so much so that in the summer they are usually dry.

3. ENVIRONMENTAL CHARACTERISTICS

3.1 Morphological and structural features

The geomorphological aspects of lagoons are not considered in this paper, only the functional morphological characteristics and above all the changes that have taken place for fishing management purposes, making a distinction between the North Adriatic valli and other coastal lagoons.

3.1.1 The valli

A fishing valle is a sector of lagoon enclosed by embankments (Colombo, 1972) and characterized by brackish water and low average depth (from a few cm to 1 m).

The main structural features of a fishing valle are embankments, sluice gates, internal canalization, fish collecting and wintering basins, fish barriers (Fig. 11-12).

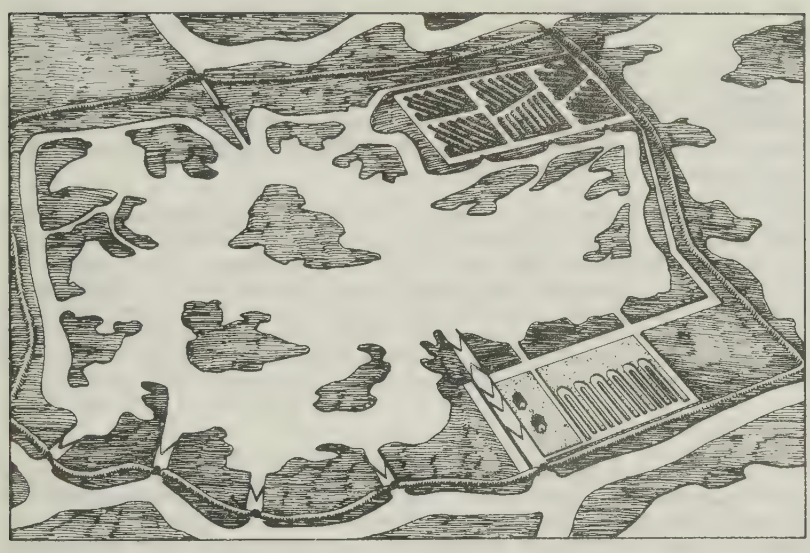

Figure 11. An embanked valle

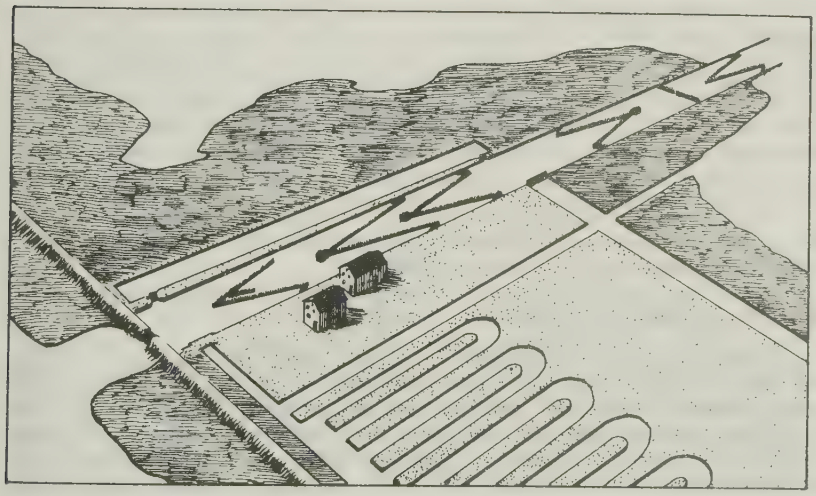

Figure 12. The fish barrier of the valle

3.1.1.1 Embankments

The valle, seasonally enclosed by reeds and vegetable fibres (serraglia) and those partially embanked, (semiarginate) represent, according to Bullo (1891), two successive stages in a unique evolutionary process that later lead to the permanent shutting of the lagoons and to the construction of embanked valle.

The embankments, made of earth, are reinforced with stones at their base, especially along the outside sectors, which are more open to wind and sea erosion. The planting of suitable vegetation improves their hold. Whenever possible, they are built sufficiently wide to be used by vehicles or mechanical means. Their height depends on the tide range: in the lagoon of Venice it is between 2 and 2.5 m on the average sea level.

3.1.1.2 Sluice gates

The embankments are broken up in some places by openings through which it is possible to exchange water between the valle and the sea and/or the lagoon, and, if there is one, with a fresh water source (Fig. 11). This exchange is controlled by sluice gates, which are manouvred according to the necessities of the valle and/or to the qualitative characteristics of the lagoon or seawater.

The number of sluice gates, and especially their total width are proportionate to the extension of the valle, but they also depend on the location, internal conformation, speed and flow of the water exchange. Normally, there are 2 to 4 sluice gates toward the sea or the external lagoon, each with several openings from 40 to 200 cm wide. The main sluice gate is situated at the level of the fish collection basin inside, and, outside, at the most suitable spot for the input of seawater, in a windward area. Its useful opening, between 2 and over 50 m, is greater than for the ancillary sluice gates. One of the sluice gates is devoted to the sectors of the valle that are used for wintering fish.

3.1.1.3 Canalization

The valle is normally subdivided into basins, owing to the presence of large emerging areas, but these communicate among themselves through canals. This subdivision is partly due to the area configuration, but often it is the result of anthropic action aimed at improving the management of the valle. Internal canals

allow the movement and circulation of the water and also the movements of the fish.

A surrounding ditch, 3 to 6 m wide and 2 to 3 m deep, runs parallel to the banks, inside the valle perimeter. Besides the obvious hydraulic role, it also offers refuge to the fish during bad weather conditions (i.e., frost).

Other canals run on the bottom of the basins, meeting in a main canal (1.5 to 2 m below the valle level) which connects the various basins with the collecting basin, behind the main sluice gate. The presence of canals is essential for the hydraulic regulation of the valle and, during the autumn, it allows fishing management: first with the propagation of the call represented by the new seawater to the most distant points, and, later, when the basins are unloaded and partially drained, with the conveying of the fish to the fish barrier.

Near the emerging areas it is typical also to have real holes (gorghi) reaching 4 m in depth, and 5 to 6 m diameter, communicating with the remaining basins: in these, fish can find refuge from sudden changes of temperature, specially in the winter (incidentally, it is also possible to fish in them).

The availability of fresh water is fundamental for the purposes of fish rearing both in summer, to adjust temperature and salinity in the basins, and in winter for a minimum of water changing and also due to the presence of a protective thin layer of surface ice, to keep higher temperatures at the bottom. If freshwater intake is not available at the surface, in some cases artesian wells are used. Nevertheless they are often insufficient in water quantity and quality which usually has the advantage of a constant temperature between 18 and 20 °C, and the disadvandage of containing quantities of ammonia, iron, etc..

3.1.1.4 Fish collecting and wintering basins

The fish collecting basin (colauro) is the canal in front of the main sluice gate where the fish come in the autumn in response to the call made by the new waters. Here the fish are captured, divided by species and dimensions and then according to the size sold or wintered. By its side are the fishing house, the storehouses, the depots and other infrastructures of the valle (Fig. 12). The colauro has concrete coated walls that can reach about 50 cm above water level. Its

dimensions depend on the size of the valle: it can exceed 100 m in length and 15 m in width.

Close to the fish collecting basin, are areas (peschiere), used for stocking the fish collected, for wintering undersized fish and for seeding of fry bought in the spring.

3.1.2 Coastal lagoons

It should be emphasized that a typical model of Italian lagoons other than the North Adriatic ones, cannot be defined since extremely different conditions may exist for each case.

Some common characteristics may be indicated: first, the tides are small compared to the Upper Adriatic, and the mouths of the lagoons often have a limited flow so that the marine species in the basins are reduced (Sacchi, 1979). Sometimes the lagoons are the remains of land reclamation (i.e., Pontine marshes), and the only freshwater source is represented more by reclamation canals than by rivers.

In the most primitive of cases, a coastal lagoon is without embankments, it receives fresh water from the hinterland without hydraulic control systems and it has one or more mouths to the sea without any defence structure against silting or changing position. The mouth has no fish barrier and there is a lack of control for the water flow. These lagoons are often used as sump pumps to remove water from the surrounding marshes which are reclaimed for agriculture. Some of these lagoons, and in particular those without embankments and without water circulation, are subject to great amounts of silt from outside and therefore to rapid filling processes. In these conditions, there is no way of controlling or managing the fish resources other than through simple fishing activities. Examples of such lagoons are, for the Tyrrhenian area, Burano, Fondi and Lungo.

The first step toward active management of fish resources is represented by the presence of fish barriers in the canals communicating with the sea. These, even if similar on principle to those of the Adriatic lagoons, have different functional characteristics. They are not, in fact, the exclusive fishing gear typical of the valle, and this is due to the difficult hydraulic management caused by lack of suitable tide levels, of fresh waters and of control possibilities of their flow. Their function is that of preventing escape toward the sea and of allowing

partial capture of the fish, as well as to maintain the potential yield represented by the fish fry of marine origin in the lagoon.

A well-structured lagoon should be organized as regards: a) botton morphology; b) external canalizations (sea and fresh waters); c) sluice gates; d) fish barrier; e) water-changing support systems (pumps).

The maintenance of suitable depths against silting by dredging is fundamental. At the same time, it is important to have internal ditches in the lagoon, both radially and circularly, so that water circulation is promoted. External canals parallel to the banks are necessary to prevent silting from adjacent marsh areas. Embankments also give solidity to the shoreline and isolation for the whole lagoon. Embanked feeding canals (carrying fresh or seawaters) are equipped with sluice gates for the control of the water flow.

The importance of fish barriers as a means of management of fish resources has already been mentioned, and more detail will be given later on.

Finally, the importance of a means to exchange water should be stressed considering the serious pollution affecting freshwater inlets in most of the Italian coastal lagoons. This situation can cause serious dystrophic crises in the summer. It is often necessary therefore to be able to rely on water sources (i.e., through pumping) in those places where the pollution risk is greatest. Operations of this kind are carried out, for example, in the lagoons of Orbetello and Monaci.

3.2. Biological features

3.2.1 Trophic status

Brackish ecosystems, in their intermediate position between inland and sea waters and as receivers of nutrients of continental origin, are, at least in the Mediterranean region, among the most productive water environments (Sacchi, 1973; Carrada, 1973; Quignard, 1984; Kapetsky, 1984).

At present in many Italian coastal lagoons there is an increasing trophic status because of inputs of organic pollutants. In well-managed lagoons this situation can lead to a growing trend in fish yield (Kapetsky, 1984) as in the Orbetello lagoon, but often causes a dystrophic

status with periodic mass mortalities (Regione Toscana, 1978; Ardizzone, 1985).

Dynamics of energy transfers are far from simple, notwithstanding the reduced species richness and the dominance of a few species. For example, of great importance is the role of detritic and benthic elements as compared to the planktonic one as a basis of the main food chains in the lagoons (Cottiglia et al., 1983; 1983b).

Thanks to the shallow depth of most lagoons, the wind is often able to mix the whole water mass. This allows a good oxygenation of the deeper layers helping the aerobic decomposition processes of organic substances caused by silt bacteria.

In deeper lagoons with water stratification, oxygen cannot reach the lower layers and the bottom; anaerobic decomposition processes then prevail and their final products (sulphur compounds, methane, etc.) are toxic and cannot be recycled. Examples of deep lagoons in meromictic conditions caused by density are those of Fondi, Sabaudia, Lungo (Ardizzone and Rossi, 1984; Perdicaro et al.,1981; Carrada and Rigillo Troncone, 1974).

Processes of anaerobic degradation can also be observed in shallow lagoons during the summer season. High temperatures and consequent salinity increase due to heavy evaporation, together with scarce mixing of the waters, bring about a marked decrease in the dissolved oxygen. The simultaneous presence of a thick macrophyte settlement both on the water surface and on the bottom, besides catching the waters so preventing vertical circulation, increases the oxygen deficit during the night. Critical environment conditions are therefore a natural occurrence for many lagoons.

If anoxic conditions in insufficient water circulation cause the development of anaerobic degradation processes, the summer crisis then becomes a dystrophic one, which can bring about serious mass mortality, also affecting the fish species. Similar dystrophic conditions may occur for much shorter periods and during the whole year when phytoplanktonic blooming takes place. In these circumstances, the densities (cells per litre) reached in the top water layers may impair the penetration of light in shallow basins, preventing photosynthesis and triggering anaerobic degradation processes from the bottom toward the surface with consequent mass mortality (Fig. 13).

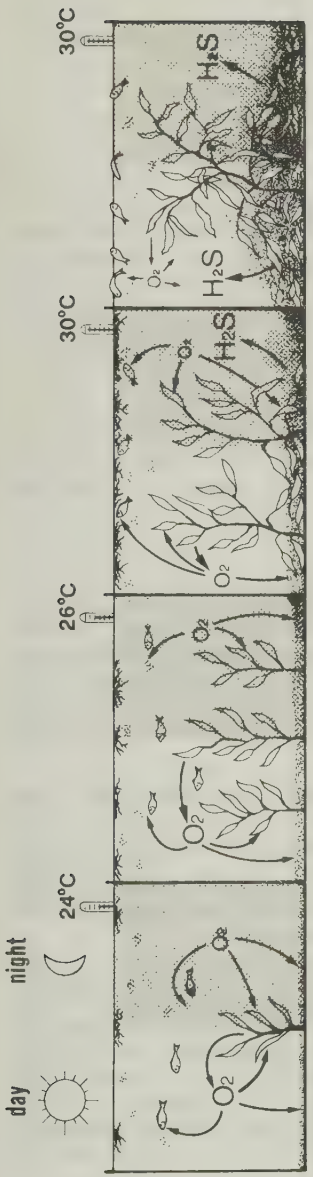

Figure 13a. Dystrophic crises caused by macrophytes

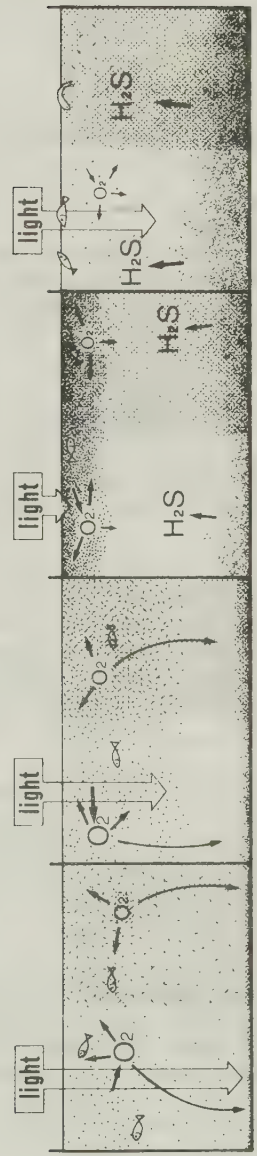

Figure 13b. Dystrophic crises caused by phytoplancton

Examples of dystrophic crises and fish mortality are reported for many Italian lagoons (Regione Toscana, 1978; Cottiglia, 1981; Perdicaro et al., 1981; Ardizzone et al., 1982; Ardizzone and Rossi, 1984 ; Ardizzone and Corsi, 1985).

3.2.2 Planktonic populations

The extreme variability of phytoplankton should be emphasized for both quality and quantity in a lagoon environment. In fact, it is possible to observe conditions of scarce presence of real planktonic forms with a predominance of benthic or epiphytic forms living passively in suspension (Marchesoni, 1954), which should be considered as ticopelagic forms (Regione Toscana, 1978). On the other hand, actual blooming of coastal species is also possible.

For example, the Orbetello lagoon has a qualitatively rich microphytic load (around 200 species) with a predominance of flagellates compared to diatoms and peridiniales, and quantitatively varying between 200 and 700 x 10^3 cell/l (Regione Toscana, 1978).

For the Pontine area (Latium) on a total of 276 species, very high phytoplanktonic densities can often be observed especially in the lagoons of Fogliano, Fondi and Lungo. The values range from 2.4 x 10^5 to 2.74 x 10^6 cell/l. Blooms have been found for Chaetoceros affinis, C. simplex, C. cfr. peruvianus, Nitzchia longispina, N. delicatissima, Prorocentrum micans, P. minimum, Cyclotella striata, Skeletoma costatum, Oscillatoria limnetica (Bazzichelli, 1985).

The studies carried out on the phytoplankton in the lagoon of Venice are numerous (see Tolomio, 1984, for reference). In particular, a predominance of flagellates, diatoms and peridiniales with bloomings of Skeletonema costatum (Voltolina, 1974) should be noted. For the bays in the delta of the river Po, an extreme variability of neritic and freshwater species has been found.

In the lagoon of Lesina, freshwater forms are limited to the farthest oriental sector, more isolated from circulation (Solazzi et al., 1972), while in the rest of the lagoon, there are abundant marine forms such as Ebria tripartita and various species of Chaetoceros.

It is important to emphasize that algal blooming occurrences should not be interpreted only in terms of

nutrients load but also in terms of biotic control processes such as for communities of phytophagus, among which are zooplankton and the filtering benthic organisms (Ferrari et al., 1984).

As far as chlorophyll-a concentration is concerned, the most frequent condition in the Italian lagoons has values comprised between 5 and 50 mg/m^3 but cases of concentrations higher than 200 mg/m^3 are also known.

Concerning zooplankton, in coastal lagoons with limited communications with the sea (i.e., Valli di Comacchio), there is a permanent native population mainly composed of meroplankton, rotifers and copepods of brackish waters, while the neritic component is extremely slight (Ceccherelli and Ferrari, 1978). In lagoons with a large extent of water flow from the sea, it is possible to identify a zonation with hydrologic characteristics over which a structure gradient of zooplankton can be found (Colombo et al., 1984). Thus it is possible to observe lagoons, or parts of them, with a predominance of coastal marine components with copepods such as Acartia clausi, A. latisetosa, Oithona nana, and lagoons in which inland species such as Calanipeda acquaedulcis and the rotifer Brachionus plicatilis, have a significant role.

Among the most abundant and frequent zooplanktonic species in the Italian lagoon environments, A. clausi is often mentioned. Recently the presence of a species morphologically very similar to, and therefore confused with A. clausi has been reported: it is A. margalefi, which should therefore be very important in the Italian lagoon environment (Coen and Mazzocchi, 1985).

The zooplanktonic role in the productive dynamics of the lagoons seems qualitatively important even if limited in terms of "standing crop." In fact, it is quite significant in the feeding of Atherina boyeri (Ferrari and Rossi, 1984) and fry (length < 3 cm) of Sparus aurata, Dicentrarchus labrax and various grey mullet (Ferrari and Chieregato, 1981).

3.2.3 Benthic communities

Three characteristic groupings may be identified regarding phytobenthic population (Giaccone, 1974): i) vegetation of aptophyte attached to natural or artificial hard substrata, ii) vegetation of rhizophyte established on soft bottom with sand and mud, iii) vegetation of secondary pleustophyte not fixed to substrata with acropleustophyte

floating on the water surface and with benthopleustophyte lying or rolling on the soft bottom.

The first grouping comprises, among others, some ulvales and species of the Enteromorpha genus which in the summer become secondary pleustophyte and should therefore be considered as part of the third grouping (floating algae). This last group include species of the genus Cladophora and Chaetomorpha which in the extent of their settlements represent a characteristic of a great part of the lagoon environments (Regione Toscana, 1978).

In brackish waters particularly rich in nutrients, Gracilaria verrucosa can be found. This red, agar-producing alga has a remarkable capacity to catch nutrients and can be cultivated on poles and ropes (Giaccone, 1978). This rhizophyte group includes some Characea (Lamprothamnium papulosum), eelgrasses (Zostera spp.) and Cymodocea nodosa in good sea-exchange conditions, while Ruppia spp. is more typical of brackish environments and is also often found in the Italian lagoons.

Concerning zoobenthos, three groups of species can be identified (Ardizzone, 1985):

i) species with marine affinity, commonly found in coastal semi-enclosed areas, which, even if reproducing at sea, prefer low hydrodynamic environments such as lagoons, bays, harbours, etc. (Giangrande et al., 1983-84; Guelorget and Perthuisot, 1983);

ii) species typical of lagoons that reproduce in halolimnobic environments, and which can stand heavy variations in the physical and chemical parameters typically found in those environments (euryecious). These species inhabit even the innermost zones of the lagoon and they can be accompanied, according to the extent of inland input, also by freshwater species;

iii) opportunistic species which, owing to their particular strategy (high turnover, brief life cycle, large ecologic valence, low competitive skill) can adapt well to particularly stressed environmental situations, such as those deriving from an eccessive organic load with consequently reduced oxygenation of the substratum which can often be found in coastal environments with limited water exchange.

The first group comprises mainly polychaetes (i.e., Perinereis cultrifera, Nereis caudata, Nainereis

laevigata), crustaceans Anphipodi (Microdeutopus gryllotalpa), tanaids (Leptochelia savigny), isopods (Paracirceis sculpta).

Typical species belonging to the second group are Nereis diversicolor and Ficopomatus enigmaticus among the polychaetes, Sphaeroma hookeri amongst the crustaceans, Cerastoderma glaucum, Hydrobia acuta and Helobia stagnorum amongst the molluscs. The last group includes mostly polichaetes (Capitella capitata, Polydora ciliata, Malacoceros fuliginosa) and larvae of dipterous (Chironomidae).

The spatial distribution of macrobenthos obviously reflects the environmental conditions of the lagoon showing the main selective factors operating in it. These should be looked at for both the degree of marine influence (extent of exchanges with the sea) and the trophic levels (extent of exchanges with the continental system) (Sacchi, 1973; Cognetti et al.,1975; Amanieu 1977; 1978-79; Guelorget and Michel, 1979 a, b; Fresi et al., 1984). Thus, for example, the six coastal lagoons of Latium show ample variation of lagoon benthic communities: from marine-like conditions, i.e., Caprolace, rather shallow and well connected to the sea (i.e. Caprolace) where there is a predominance of species of the first group, to those more confined (i.e., Fondi, relatively deep, with indented coastline and divided from the sea by two long and narrow canals), characterized by species belonging essentially to the second group; lastly to those influenced by particularly polluted organic inland inputs (i.e., Lungo and Monaci), which are characterized essentially by species belonging to the third group (Fresi et al., 1984).

In larger brackish systems, as in the Orbetello lagoon (Tuscany, Italy) which covers around 2,700 ha, it is possible to observe, inside the same environment, almost all the situations present along sea-lagoon and trophic gradients (Regione Toscana, 1978).

In particularly isolated coastal lagoons, such as Burano (140 ha, Tuscany) whose only outlet is often silted up, the zoobenthic population is almost exclusively characterized by halolimnobic and euryecious species (N. diversicolor, F. enigmaticus, Streblospio shrubsoli among the polichaetes, S. hookeri, Gammarus aequicauda amongst the crustaceans, C. glaucum among the molluscs) (Cognetti et al., 1978).

The North Adriatic lagoon environments are different from other Italian lagoons because of a series of ecological characteristics that are closer, in certain ways, to those of estuary environments, as, for example, the remarkable extent of the tide (as compared to Tyrrhenian lagoons), the bordering of a rather shallow and eutrophic sea, a climate generally more continental and less warm (Sacchi, 1979).

From the zoo-geographic point of view it should be noted that there is a presence of oriental elements in various zoobenthic taxa, such as, for example, bryozoans, hydroids, amphipods, pycnogonids, isopods (Sacchi et al., 1982). The zoobenthic communities are in general relatively poor, made up of euryecious and opportunistic species reaching considerable densities, while the marine species that penetrate such environments do not, normally, give origin to any permanent settlements. In the Sacca del Canarin (delta of the Po River), for example, the species richness is greater in limited areas influenced by the sea while in muddy silts there is a predominance of polychaetes Streblospio shrubsolii and Heteromastus filiformis (Ambrogi et al., 1983).

The floods of the Po River have a negative influence on the zoobenthos, keeping such settlements in the conditions of "pioneer settlement". The evolution toward more stable and better structured biotic communities is tied to smaller and more constant river inputs and to good vivification (Ambrogi et al., 1983). In the lagoon of Grado and Marano (12,717 ha), there is a predominance in the brackish areas of Scrobicularia plana, a typical estuary bivalve, and of dipterous larvae (Vatova, 1979).

In the Comacchio Valli (around 10,000 ha), marine species are uncommon and coexist with a typically halolimnobic fauna, among which F. enigmaticus, N. diversicolor, Balanus eburneus, C. glaucum (Cognetti et al., 1975). The biomass values for the zoobenthos at Comacchio vary between 1.54 and 9.08 g/m^2 of dry weight (Colombo et al., 1977).

4. EXPLOITED FISH SPECIES

The fish fauna of commercial interest in Italian coastal lagoons is mostly made up of euryhaline species. The number of species and the abundance in each species differ according to the environment and depend on both natural fry ascent from the sea and on seeding by man.

The marketing of different fish species is peculiar. Fish such as sea bass and sea bream have high commercial value and strong market demand during the whole year. The eel market is mostly concentrated in the winter period and particulary for the traditional Christmas consumers (D'Ancona, 1940; Gatto et al., 1979; Cognetti and De Angelis, 1980).

Different conditions are present for the grey mullets: first Chelon labrosus, then Mugil chelon and Liza aurata are the most appreciated species. L. ramada and L. saliens are low-priced species. Differences in commercial value are common in various Italian markets, particularly due to origin and preparation of product.

4.1 Eel (Anguilla anguilla)

Italian names
Yellow eel : anguilla gialla, pantanina, bisatto, pasciuto
Silver eel : anguilla argentina, maretica, femenale, filatrotta

Life cycle in lagoon

Fry entering inland waters are called ceche (glass eels), and are completely transparent. In the next stage eels pigment progressively and grow and are called ragani (elvers). They then have a dark-green or grey back and a light or yellowish abdomen and are called yellow eels. At the start of sexual ripenings the eel changes its appearance: its back becomes black, its abdomen silvery (from which the name of silver eel), and its eyes larger.

From a sedentary yellow stage, the eel change its behaviour migratoring to the sea for reproduction.

Growth

Females reach larger sizes (over 1 m and 3 kg) than the males (not over 45-50 cm and 150-200 g). Three to five years are necessary for the males with final sizes of between 100 and 150 g and 4 to 7 years for females (between 200 and 500 g) to reach the silver stage in northern Italy. In the south the same sizes are reached one year earlier.

Feeding habits

The eel is omnivorous but preferably carnivorous and shows twilight and/or nocturnal activity.

Reproduction

The only known reproductive area of this species is the Sargassum Sea.

Fry ascent

Glass eels migrate from the sea from October to February.

Fishing methods

Yellow eels are fished inside coastal lagoons with fyke nets and silver eels at fish barriers during migration (autumn-winter).

Aquaculture

Intensive aquaculture of eels is developed in Italy beside extensive activity in coastal lagoons.

Market

Eel is an important species in Italy. The price (1986) ranges between 8 and 12,000 lire/kg. Especially requested are silver eels over 200 g in the summer (tourist season) and winter (during Christmas). For small-size yellow eels in non-Adriatic areas, the price varies between 5 and 8,000 lire/kg.

4.2 Sea Bass (Dicentrarchus labrax)

Italian names: Spigola, branzino

Life cycle in lagoons

Fry entering inland waters have a fast growth. Sea bass can live a long time in coastal lagoons reaching sometimes 7-8 kg in weight because they are not very attracted by the autumn call of seawater at the fish barriers and prefer to take refuge in holes and ditches inside the lagoon.

Growth

In 2-3 years it reaches the commercial size of 250-400 g.

Feeding habits

The sea bass is the major predator fish in coastal lagoons: it eats sand smelts, elvers, crayfish, crabs, small gobies, but also molluscs and polychaets.

Reproduction

It reproduces only at sea in winter.

Fry ascent

The fry carries out its trophic migration to lagoons in spring.

Fishing methods

Hard-to-catch fish species. Both in the fish barriers in autumn-winter and with fishing nets.

Aquaculture

Extensive and intensive aquaculture are well developed in Italy. Artificial reproduction allows a fairly good production of juveniles for intensive systems.

Market

It is one of the most highly priced fish species, reaching over 25,000 lire/kg (1986). Juveniles for aquaculture captured from coastal waters cost 250-350 lire/each and those from artificial reproduction (90-100 days) 700-900 lire/each.

4. 3 Sea Bream (Sparus aurata)

Italian name: Orata

Life cycle in lagoon

Fry enter coastal lagoons and can reach commercial size in one year. Sea bream is very sensitive to cold and often can be killed by low temperature of coastal lagoons in North Italy if it cannot reach the sea.

Growth

Its growth is very rapid. In suitable environments, rich in benthic settlement it can reach an average of 150-200 g at the end of the first year, 400 g in the second and 800 g in the third year.

Feeding habits

It mainly eats molluscs, also lamellibranchs (mussels, clams, oysters), the shells of which it can break thanks to its molars.

Reproduction

It reproduces only at sea at the beginninig of winter.

Fry ascent

Fry carry out trophic migration to inland waters starting in February, about one month earlier than sea bass.

Fishing methods

It is one of the easiest species to fish, since, it shows up at the fish barriers with the first cold. Trammel nets and gill net are employed inside coastal lagoons.

Aquaculture

Extensive and semi-intensive aquaculture are well developed in Italy. Artificial reproduction cannot produce large numbers of juveniles. For this reason, intensive aquaculture is a rather limited activity, depending on wild fish fry availability.

Market

It is one of the most highly priced fish species reaching up to 26,000 lire/kg (1986). Juveniles captured for aquaculture purposes in coastal waters quote 800-1,200 lire/each.

4.4 Common Grey Mullet (Mugil cephalus)

Italian names: Cefalo, Meciato, Volpina

Life cycle in lagoon

Fry entering inland waters adapt well to seawater and also to brackish and fresh water where, however, they do not reproduce.

Growth

A different growth occurs for the two sexes: males reach between 500 and 700 g in 3-4 years, while females can exceed 1 kg.

Feeding habits

Phytoplankton and detritus feeders. Occasionally, they it can feed on molluscs and insect larvae. The inorganic component of the diet is around 250 mμ.

Reproduction

Reproduction is at sea between August and October.

Fry ascent

The ascent of the lagoons takes place in autumn but it is more abundant in spring.

Fishing methods

It is a suspicious fish species. At the end of summer it appears at the fish barriers. During the whole year, it is captured inside the lagoon with trammel gill and surrounding nets.

Aquaculture

Extensive and semi-intensive aquaculture.

Market

Among the Mugilidae species it is fished heavily both for its quality and for the bottarga which can be obtained, through salting, from the roes of the females. The selling price (1986) can reach 7,000 lire/kg.

Juveniles captured for aquaculture quote 20-30 lire/each in autumn and 100 lire/each in spring.

4.5 Thin-lipped grey mullet (Liza ramada)

Italian names: Calamita, Botolo

Life cycle in lagoon

Fry entering inland water can adapt well to very euryhaline conditions. They reproduce only at sea.

Growth

It has a slow growth, reaching 300 and 400 g in 3-4 years.

Feeding habits

As the other Mugilidae, it is an omnivorous species preferring soft to fine muds around 60 mμ.

Reproduction

At sea between September and December.

Fry ascent

The ascent of the lagoons takes place in spring.

Fishing methods

It is captured inside the lagoon with trammel, gill and surrounding nets, in autumn at fish barriers.

Aquaculture

Extensive and semi-intensive aquaculture.

Market

It is a low-priced species. The selling price (1986) is between 4,000 and 6,000 lire/kg. Juveniles for aquaculture quote in spring around 10 lire/each.

4.6 Leaping grey mullet (Liza saliens)

Italian names: Verzelata, musino

Life cycle in lagoon

It is the most abundant species in the upper Adriatic. Fry entering inland waters tolerate low temperatures and low salinities. They reproduce at sea.

Growth

It is a slow-growing species. In 3-4 years it reaches approximately 300 g.

Feeding habits

It is an omnivorous species feeding mainly on detritus.

Reproduction

It has the longest reproduction period among the Mugilidae, from the end of spring to the end of summer.

Fry ascent

The fry can be seen ascending both in autumn and in spring.

Fishing methods

It is captured inside the lagoon with trammel, gill and surrounding nets and in the canals at fish barriers.

Aquaculture

Extensive aquaculture in the north Adriatic valli.

Market

This grey mullet has the lowest economic value. In 1986, it sold between 4,000 and 5,000 lire/kg.

4.7 Golden grey mullet (Liza aurata)

Italian name: Lotregano

Life cycle in lagoon

It is the least tolerant species to extremes of temperature. Fry entering inland water are not well adapted to very low salinities. They reproduce at sea.

Growth

It is a slow growing species. In 3-4 years it can reach 300 g in northern Italy. The same weight can be reached one year earlier in the south.

Feeding habits

It is an omnivorous species preferring sand bottoms with marine salinity.

Reproduction

It reproduces from the end of summer until November.

Fry ascent

Fry ascent occurs in the spring.

Fishing methods

With the first cold it is captured at fish barriers. Inside coastal lagoons with trammel, gill and surrounding nets.

Aquaculture

Extensive and semi-intensive aquaculture.

Market

Among the Mugilidae it is highly valued, with prices as high as 7,000 lire/kg (1986). Juveniles for aquaculture cost around 15 lire/each.

4.8 Thick-lipped grey mullet (Chelon labrosus)

Italian names: Bosega, cerina

Life cycle in lagoon

It is a euryhaline species with clear preference for marine salinity. It reproduces at sea.

Growth

It is a fast-growing species reaching 1 kg in 4 to 5 years.

Feeding habits

It is an omnivorous species favouring hard substrata rich in fouling organisms.

Reproduction

It reproduces at the end of winter, specially in February-March.

Fry ascent

Fry ascent takes place in the May-June period.

Fishing methods

At the fish barriers in autumn-winter. Inside coastal lagoons with trammel, gill and surrounding nets.

Aquaculture

Extensive and semi-intensive aquaculture.

Market

Among the Mugilidae it is one of the most caught for its economic importance (up to 7,000 lire/kg in 1986).

4.9 Other species

Besides the fish species already mentioned, there are others in Italian coastal lagoons, some resident and able to reproduce in them, others penetrating into them following the current flow but which, not being euryaline, only feed and grow according to their feeding habits.

The former group includes Aphianius fasciatus, not edible; Atherina (Hepsetia) boyeri, Zosterissessor ophiocephalus, Pomatoschistus spp. Among the crustaceans, Crangon crangon, Palaemon spp. The latter group includes Lithognathus mormyrus, Diplodus annularis, Mullus barbatus, Solea vulgaris and Platichthys flesus luscus.

Among aquaculture activities in Italian coastal lagoons we must remember mussel culture, particularly in the Grado-Marano and Venice lagoons and in the Po delta bays for the Adriatic area and in coastal lagoons of the central Thyrrenian sea (Scalfati, 1970).

The most common Italian culture technique makes use of poles driven into the lagoon floor and connected by ropes outside the water, called pergolari. Mussels are reared on vertical ropes connected to the horizontal ones.

One hundred structures for mussel culture operate in the Venice lagoon with an annual yield of 25,000 tons in 1977 (Zerbinato, 1981).

5. FISHING GEAR

5.1 The fish barrier

The origins and development of fixed fishing gear based on the principle of V-shaped traps are not easy to

pin down both from the historical and geographical points of view. In fact, it is possible to find fishing methods based on V-shaped systems, ranging from simple basket traps to sophisticated systems of fish barriers in every part of the world.

The fish barrier has become more and more important in the productive management of Italian coastal lagoons; this importance was stressed by technological progress which led to the creation of complex structures, in which functionality was strictly connected to specific bio-engineering principles.

In fact the level of experience reached by the Italians is such as to make this fishing-trap-barrier a real means of resource management.

Although some historical facts date this invention back to the 1500s-1600s, according to Bellini (1899), the origins of the fish barrier of Comacchio are much more remote, since such a complex fishing system could have developed only after a long evolution (Fig. 14).

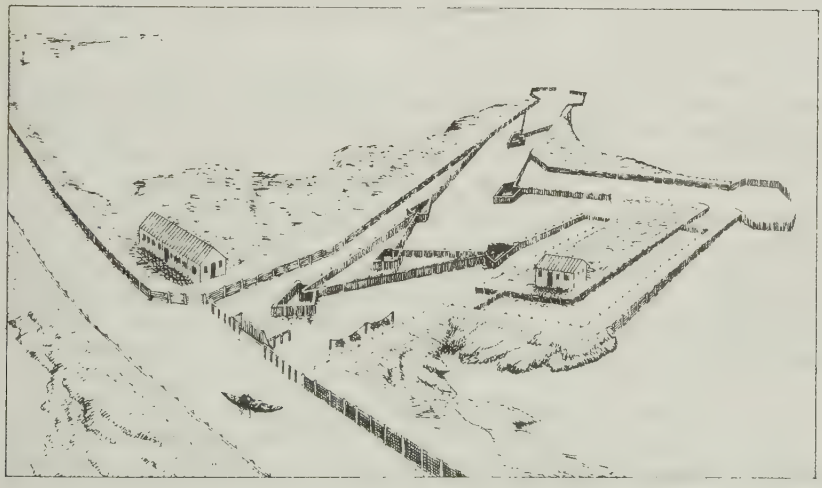

Figure 14. The fish barrier of Comacchio from Friedlander (1872)

According to the sources of Ferrari and the historian Ferri from Comacchio, the fish barrier of Comacchio are ascribed to the Guidis (XVIth century), who were allowed by the dukes of Ferrara to decorate their coat of arms in memory of this invention. However, Bellini (1899) points out that the fish barrier is mentioned in an edict of Comacchio dated 1494, thus corroborating his theory of more remote origins.

Nevetheless, it is probable that the fish barrier was modified in the XVIth century in such a way as to be considered a new invention (Felletti-Spadazzi, 1977). This brief historical summary may be concluded by citing Del Rosso (1905) who mentions Roman V-shaped barriers, quoted by Plinio, which were called excipule and used in Lake Benaco to catch eels; furthermore, describing Etruscan and Roman fish ponds used in coastal lagoons, the author refers to very complex capture systems.

5.2 Evolution of the fish barrier

The first fish barrier was made of reeds and the capture chamber was either square or circular (Fig. 15 A).

Later, considering the resistance of these shapes to water flow which threatened to break of the trap, the structure of the chambers was modified to heart or arrow pointed shapes (Fig. 15 B)

The size of the capture chambers was obviously small, which made it necessary to place two or four reed walls before the first one (Fig. 15 C), these also converged and opened at the apex to prevent the fish from escaping as they found the chamber full of preys.

Subsequent improvements involved the separation of different species and sizes, above all eels and grey mullet (Bellini, 1899),in order to avoid doing it when the fishing was over. The innovation probably consisted in placing another chamber before the first one (Fig. 15 D); this, made of more scattered reeds, allowed eels to get through while stopping other species.

As this structure (called baldresca in the typical fish barrier) proved effective, two other side chambers (otele) were incorporated to catch the fish that tried to go back before being pulled in the final chamber (Fig. 15 E).

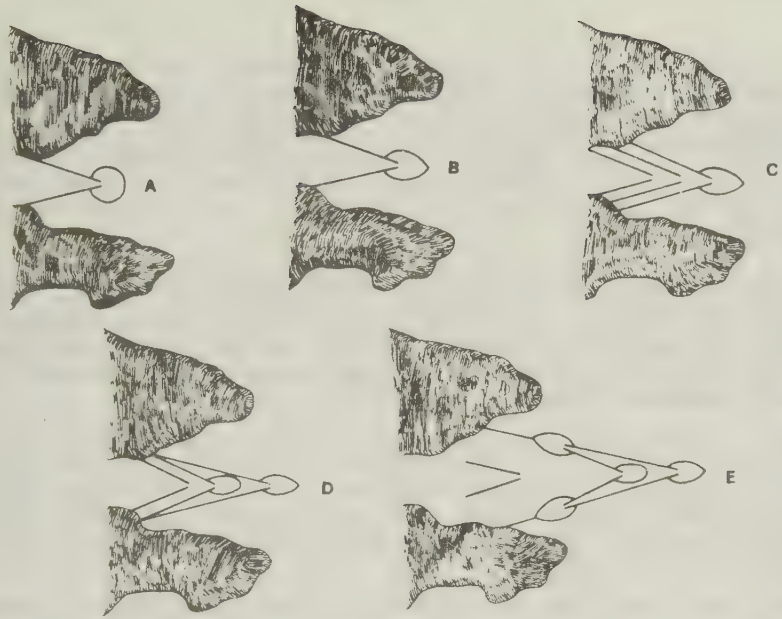

Figure 15. Evolution of the Italian fish barrier (lavoriero).

These are the basic steps in the evolution of what is now called the fish barrier at Comacchio; it has had such a shape since the XVth and XVIth century (Bellini, 1899). Bellini suggested creating a new type of fish weir, where the grids were not made of vegetable matter but of a 4-mm mesh metal net, supported by frames. However the design of the general barrier was not changed.

Toward 1930, the Italian specialist G. Bullo carried out a plan for the building of fish barriers of the northern Adriatic type to be used along the Tyrrhenian coast (Monaci and Fogliano lagoons). This plan marked a considerable advance in the use of new materials, as the new fish barrier was made of concrete pillars supporting movable metal grids.

Commonly used in the valle, the Adriatic fish barriers style was applied to Tyrrhenian lagoons with innovating criteria.

Observing the technological features of the fish barriers we can sum up some essential points:

i) Considering the evolution of design and materials function, the north Adriatic fish barrier is the most advanced form of fish trap in the lagoons. Even though some adaptations were required, the fish barrier spread to other Italian lagoons thanks to the experience acquired in the valli, moving from traditional scheme made of reeds and paling to modern fish weirs made of concrete and metal grids.

ii) Economic rather than technological problems seem to have caused the appearance of modern fish weirs (De Angelis, 1959). The changed social conditions of workers and the consequent increase in the cost of labour made the fish barrier too expensive to be constructed periodically with vegetable fibres.

iii) The functional evolution of the fish barrier has tended to make this gear selective. In fact, it is possible to separate different species, save juveniles and selectively capture also those species that migrate from the sea into the lagoon in the form of adults and sub-adults.

iv) As the use of building materials evolved, the design changed as well. Since the spaces between the reeds were very narrow, the traditional fish barrier had to be very long in order to ensure the necessary water movement. This was the reason why V shapes were adopted. Thanks to the metal grids, the modern fish barrier ensures good water exchange so that it can also be placed across the canals.

5.2.1 The fish barrier in valli

Figure 16 A shows the shapes of traditional fish barriers used in valli. Through the sluice gate (1) at the mouth of the external lagoon, it is possible to regulate the water flow toward the valle to attract the fish. There is a first safety barrier (2), which can also capture fish and another one (3) consisting of thin grids that hold eels back as they get away more easily than other prey. In the central part of the device are those barriers that make possible most of the captures. These are the effective fish weirs, working both during flood tide (4) and low tide (5) when the waters come from the valle.

Finally, a door (6) separates the fish barriers from the valle and another barrier (7) prevents the fish from going toward the sea when, during non-fishing periods, the water inlet from the lagoon to the valle is activated.

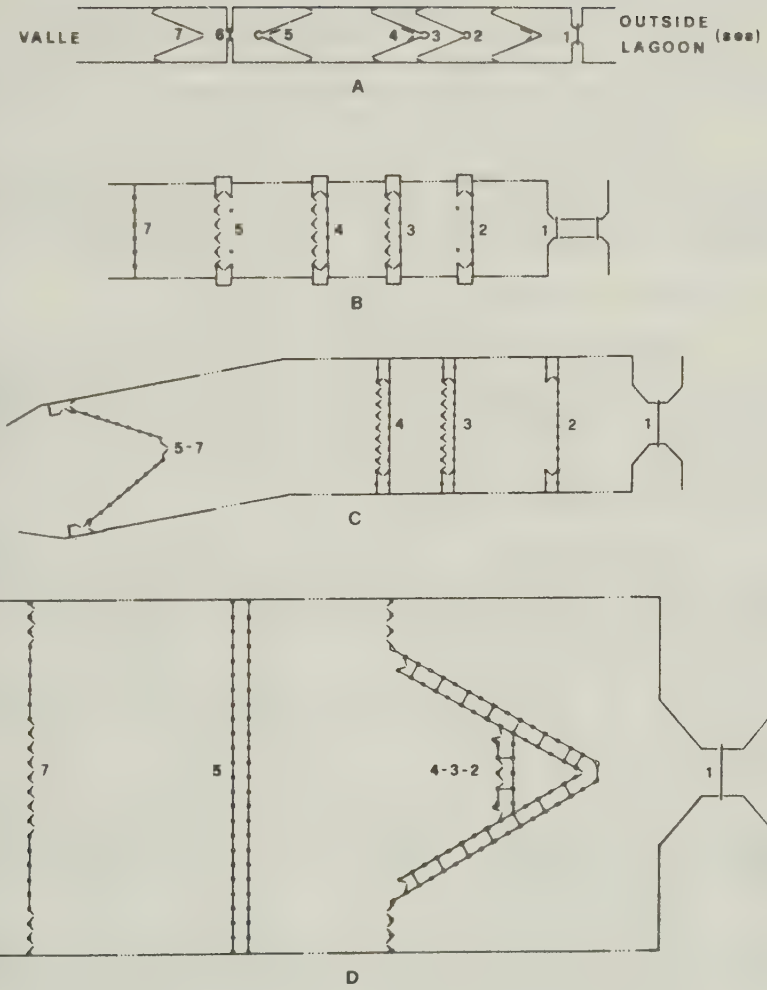

Figure 16. Shapes of barrier used in valli (see 5.2.1)

The original V plan can be changed thanks to the presence of metal grids which allow a better waterflow (Fig. 16 B). In modern weirs, the number of barriers can sometimes be reduced, for example by creating special structures (Fig. 16 C, 5-7) that can both keep the fish in the valle during the opening of the canal and catch the fish when the tide is low.

The whole plan can also be reduced concentrating the functions of the first barriers in a single V-shaped structure (Fig. 16 D, 2-3-4) and using the other two barriers to control the fish during opening operations (Fig. 16 D,7) and for low-tide catch (Fig. 16 D,5).

5.2.2 The fish barrier in coastal lagoons

Lagoon fish barriers have two typical basic shapes. The first (Fig. 17 A) is provided with two mouths for the running up of juveniles (1) and one mouth for catching adults (2). The second (Fig. 17 B) can capture adult fish both going in and out of the lagoon. The fish come from the sea through the mouths (1) and get into space (5), while the narrow mesh of the second barrier (3) allows only juveniles to reach the lagoon.

During migration to the sea, the fish swim into space (5) through the mouth (4) and continue during flood tide, to be caught by the following barrier (2). They can also be captured in space (5) by means of other fishing gears (fyke and other nets).

Another evolution of the original design is that of Figure 17 °C with most of the canal taken up by capture fish barriers and part (1) for the entering of the fish from the sea.

The use of new materials such as concrete and metal made the design of the lagoon fish weir evolve gradually so that it can be placed crosswise to the canals to ensure a higher hydrodynamism.

The fish weir used at S'Ena Arrubia, Sardinia (Fig. 17 D) is provided with only two series of small concrete pillars. With the changing of the arrangement of the grids, the functionality of the fish trap varies. Positioned in (1), the barrier facilitates the running up of the fish from the sea into the lagoon. In position (2), the same barrier is arranged for flood tide catch when the fish migrate toward the sea.

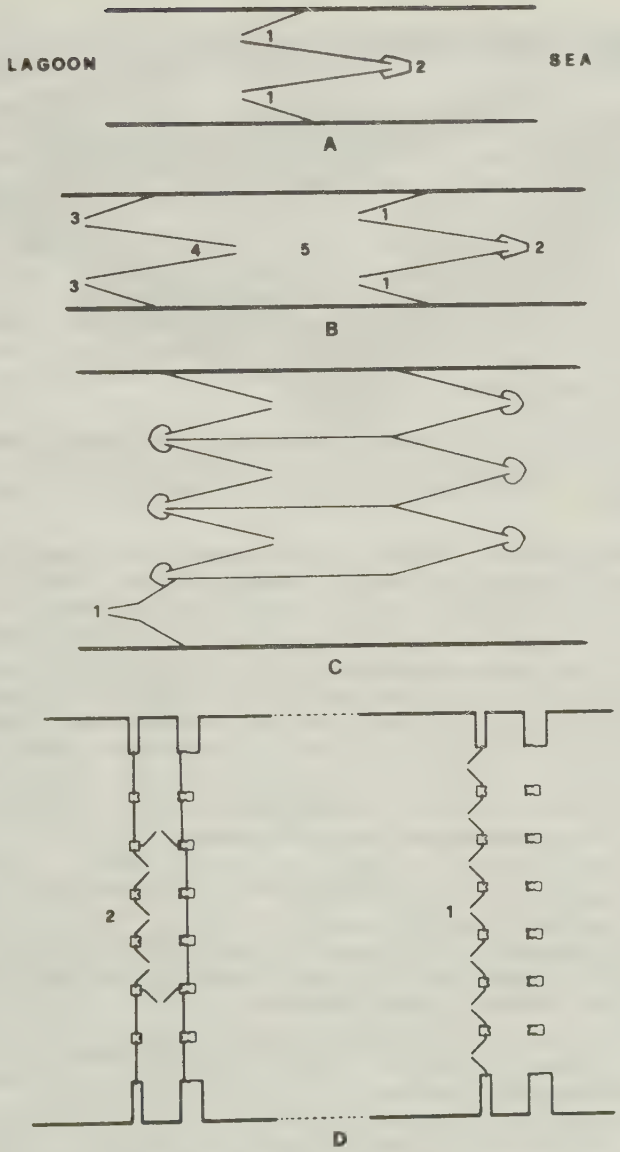

Figure 17. Shapes of barriers used in lagoon (see 5.2.2)

5.3 Lagoon fishing gear and techniques

The variety of the lagoons located in different latitudes along the Italian coast and characterized by various traditions resulted in fishing techniques that evolved according to local necessities. As time went on, these techniques tended to have the same structure due to the widespread availability of industrial raw materials. However, fishing methods and the design of some catch devices remained the same in some areas due to persisting traditions and some particular adaptations to the characteristics of the environment. This happened above all for fyke nets. In the following description, we will consider some historical aspects analysing some particularly important areas.

Fishing in the Venice lagoon was thoroughly described by Ninni (1940), who classified 28 types of nets, grouped in trawls, nets composed of barrings and basket traps, and free nets.

De Angelis (1963, 1964) described the fishing techniques used in Lesina and Varano lagoons, Apulia. These were also widely used in other south Mediterranean lagoons, where Apulian lagoon fishermen had worked for a long time, spreading lagoon eel fishing methode. Among other catch devices, the author describes the grisciola, a particular system of fish barrier made of vegetable fibres and composed of many chambers, used for catching the fish that migrated toward the sea without closing the whole canal (Fig. 18).

As lagoon fishing techniques evolved, the number of the devices used progressively decreased.

Certain devices, such as nets, fish weirs, basket traps, harpoons, fishing lines were adapted to local necessities with different names. Fishing was carried out by professionals, but also by occasional fishermen, who acting within or against the law, made use of devices that were not so expensive as harpoons.

At present fishing is carried out by means of fish barriers, nets and fyke nets; fish hooks are used by professionals only rarely.

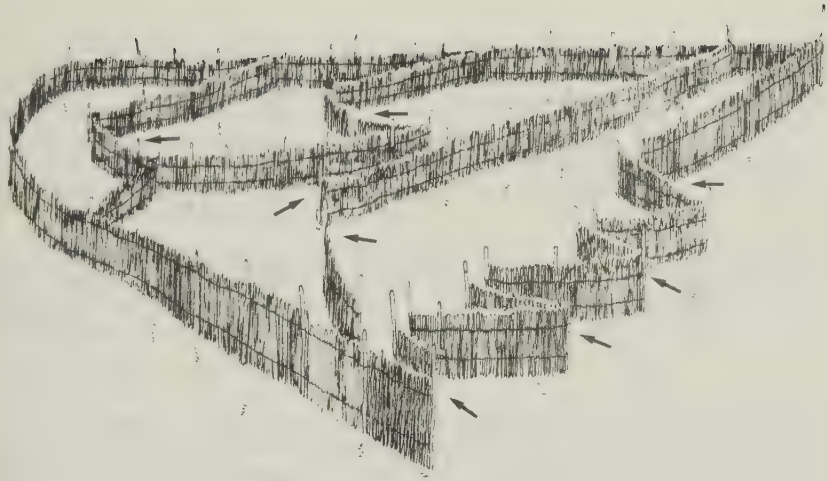

Figure 18. A particular mid-water fish barrier from Apulian lagoons: the grisciola.

5.3.1 Fyke nets

In lagoon fishing, basket traps are integrated with fixed structures, such as enclosures and barriers, to divert the movements of the fish into the catching device. They are principally used for catching eels and their importance is proportionally greater in those lagoons lacking fish weirs or where yellow eels are usually caught.

The migration of eels can be controlled by means of special combinations of fyke nets and barring nets, sometimes arranged in a complex way.

Where lagoons lack fish barriers, traps consisting in a simple arrangement of nets and fyke nets (Fig. 19) are employed in the canals linked to the sea in order to avoid the impact of the current; very complex combinations, measuring up to 100 m in length (Fig. 20), are instead placed in the lagoon before the opening of the canals.

In some lagoons (i.e., Lesina) these barriers almost close the lake from one shore to the other and each fishing station, composed of many hundreds of fyke nets, is managed by a group of fishermen.

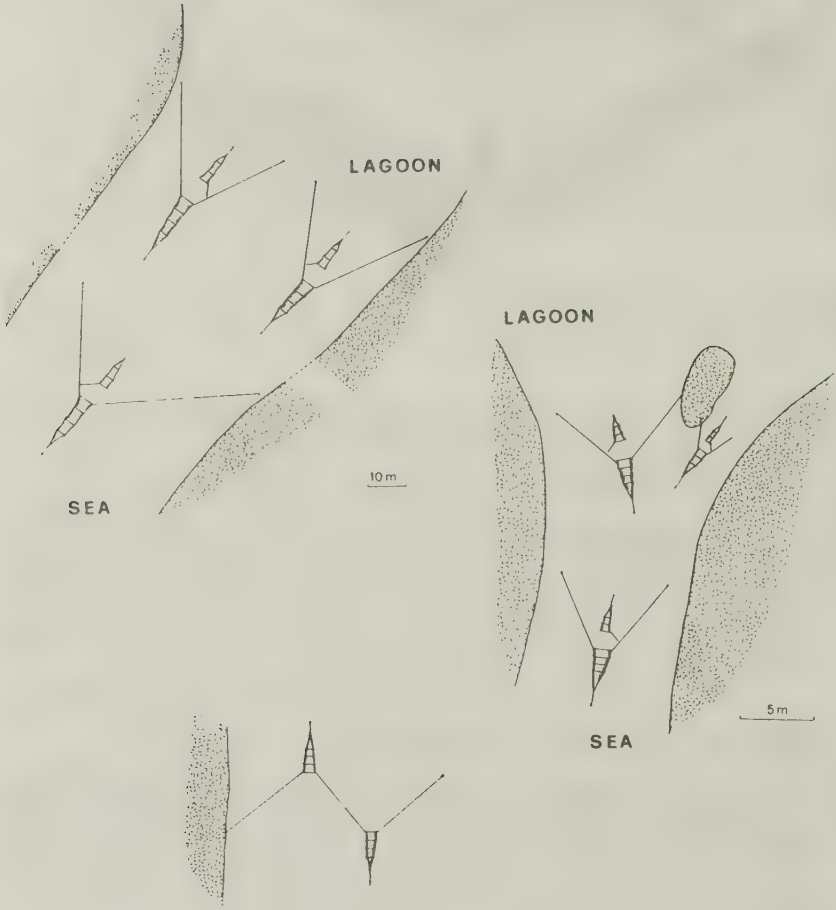

Figure 19. Barring nets and fyke nets in canals lacking fish barriers

The structure of fyke nets has evolved, as well as the way of using them. There are many kinds of fyke nets, ranging from the simplest (Fig. 20 F) used along shores, often among the reeds, to catch grey mullet or eels up to those employed together with barring nets (Fig. 20 A - G). As the size of these complex structures becomes larger and long wings are added, the number of fyke nets they consist of gradually decreases.

These fishing gear are mostly employed in orthogonal position with respect to the shores of the basins, so barring the movements of eels; they can also be placed in the middle of the lake, if it is not too deep.

5.3.2 Other nets

Trammel nets and gill nets are the main fishing gear used for fin-fish such as grey mullet, sea bream and sea bass, particularly in coastal lagoons without fish barriers. Until a few years ago, the only device used was the trammel net; the gill net has been used only recently.

In sufficiently deep lagoons, local fishermen use surrounding nets to catch grey mullet.

Another fishing gear is the seine net, although it is used less and less because of its scarce selectivity, which causes high death rates in juveniles. Now it is used almost exclusively for sand smelts.

Other fishing gear such as harpoons and long-lines are not used any longer in most Italian lagoons.

It is worth giving a brief explanation of the cages commonly used for eels to preserve animals alive for long periods (at Christmas-time), so as to get the best selling prices. Only rarely is it possible to select eels by means of the fishing gear, as the eel is able to "push" with the tail, so breaking the mesh and escaping, if a mesh larger than a certain size is used. The selection is therefore made later in the eel cages made of hard materials (wood, wicker, iron), which allow small animals to go out.

6. STOCK EXPLOITATION AND FISH YIELD

6.1 Traditional fishing management

Lagoon management consists in traditional methods of so-called extensive breeding, based on cycles completely supported by natural productivity. In certain valli, it is

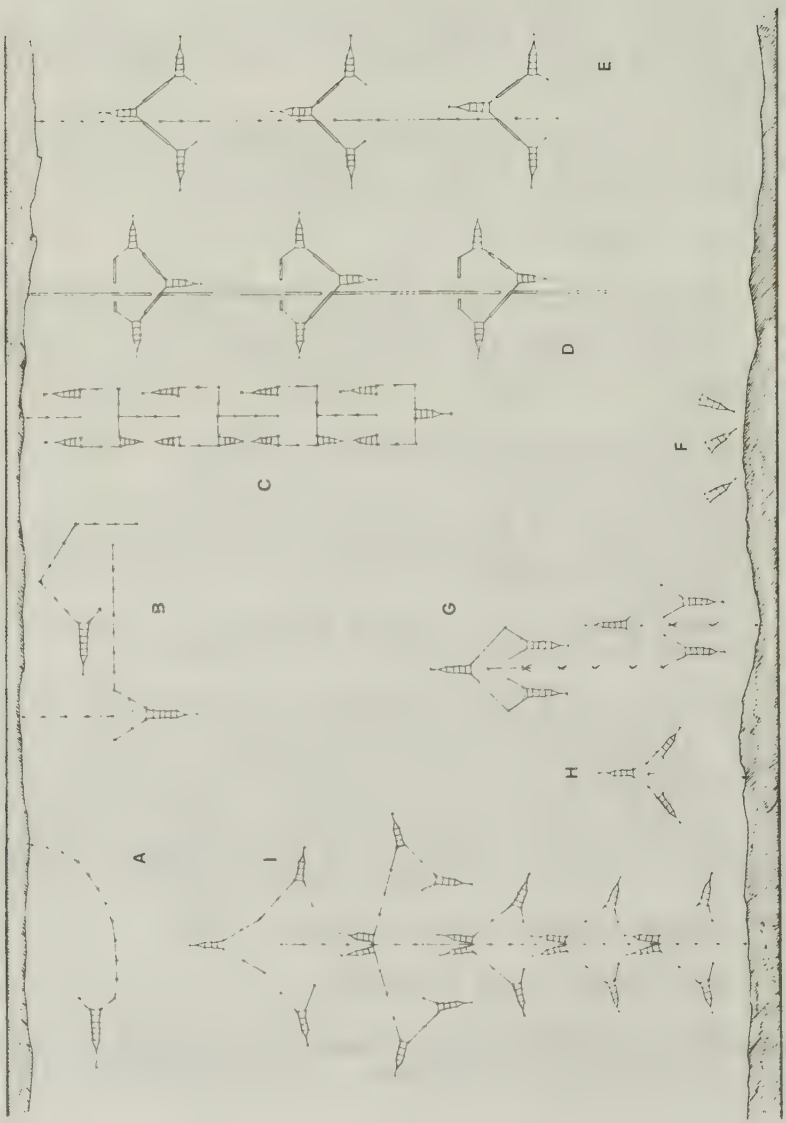

Figure 20. Arrangement of nets and fyke nets inside Italian coastal lagoons

supplemented by other methods that sometime involve the use of artificial food. Food can be used for feeding a number of juveniles in special basins during the first 2-3 months (pre-fattening); for feeding some species of grey mullet during the first year and sometimes also during the second (semi-intensive); or even for some fattening before putting the fish on the market.

The traditional system essentially consists of mixed breeding, since different species with individuals of all sizes are bred in the extensive basins at the same time. It is clear that growth is proportional to the biological characteristics of each species and to the availability of food in the environment.

The negative aspects of this breeding technique are competition and predation, which can also result in cannibalism. As a consequence, only few fish survive and the catch composition is not proportional to the seeding. Besides the impossibility of intervening on fish growth and survival, other problems connected with extensive breeding are the length of the breeding cycle and the very low yield compared to the land utilized.

An annual cycle includes some basic phases: fry stocking, growth, catch and sale or wintering of the fish. The valle cycle begins in spring, when the fry is let into the basins and goes on with those operations that allow its preservation and growth. The final catch phase may take place after only 1-2 years (for sea bream) or up to 6-7 years (for eels). On the contrary, fry stocking in lagoons is mostly natural and ordinary artificial stocking is still sporadic.

One of the fundamental problems in valle management is the overcoming of the winter phase: as said above, only sea bream reach a harvestable size at the end of the first breeding year. As far as other species are concerned (grey mullet and sea bass), it must be reckoned that they barely stand low winter temperatures; below 4-5 °C the risk of death is very high. In autumn, when all the species bred (except yellow eels) tend to leave the valle under the effect of their reproduction and of thermic impulses, whatever their age, and gather in the collecting basins, it is the time to favour the entry of the immature fish that cannot be sold on the market into special wintering fish ponds. Only eels can remain quiescent in the valle, by sinking in the mud.

The basis for the success of these methods are those operations that concern the valle management, i.e., interventions to control the internal water flow and the hydrobiological balance of the environment.

The more southern geographical position of the other Italian coastal lagoons (Ravagnan, 1981) and the shape of their basins make the wintering problem less urgent; in fact, normal lagoon management does not include such a problem in these areas. On the other hands, hydrological management is fundamental in every coastal lagoon, even though it is used for different purposes.

6.1.1 Hydrological management

Hydrological management is based on 1) the constant opening/closing of the sluice gates to regulate seawater inputs (quantity and quality): 2) the periodic inlet of fresh water; 3) the movements of internal water masses. The regulation of the sluice gates depends first on the requirements of breeding, but also on the distance from the sea, the tide extent and the physical and chemical characteristics of internal and external waters, in order to obtain the best conditions of temperature, oxygen and salinity. In the North Adriatic the tide extent is around 1 m, which is sufficient. However, many valli are provided with water-scooping machines to improve both charge and discharge and internal circulation. Management choices are made according to the experience of the single manager. Nevertheless, there are some general needs and rules in valle management that can be summarized up as follows.

i) Spring. The valle water is changed as much as possible: the outflow of brackish water attracts young fish running up naturally. As soon as seeding is done the water is raised to the highest level.

ii) Summer. In this season the water level progressively decreases due to evaporation. It is necessary to refill with fresh water to moderate salinity, carefully taking into account possible dystrophic phenomena resulting from the eutrophization of the valle.

iii) Autumn. Water is reduced to the lowest level to foster the gathering of the fish in the channels. Usually at moon dark in October (rarely in September), the inlet of seawater flows during the peak of high tide stirs the migration instinct of the fish, which gather in the catch gear. In this period the sluice gates are lowered to empty the valle during low tide and to foster fishing during high tide.

iv) Winter. Once fishing is completed, the basic problem is to assure the best conditions of temperature and oxygen in the wintering fish ponds, where the immature fish is kept for wintering. For this purpose, the water level must be kept as high as possible. What is particularly important is the availability of fresh water (excellent is the water of artesian wells, whose temperature is generally not lower than 15 °C), which forms a thin layer of ice on the surface sheltering the fish from sudden changes in temperature.

Particularly important for hydrological management is the maintenance activity that concerns the control over internal and external embankments and device (sluice gates and fish weirs), the excavation of fish ponds and of the principal canals that naturally tend to silt up, the weeding of the embankments and the algae removal from the bottom.

It must be said that, in coastal lagoons without fish barriers, it is not always possible to carry out active hydrological management as many of them are not provided with sluice gates in the canals linking them to the sea and fresh waters. Water inflow and outflow are therefore related to tide rates, sea storms, rainfalls etc. Where control systems for water flow exist, they are used for water exchange and for influencing the fish movements.

Water exchange is particularly necessary in spring to control possible dystrophic crises and in those lagoons with strong eutrophic inlets. The necessity of controlling fish movement is instead linked to the running up of the juveniles and to the catch of adults by means of fish barriers. In fact, the essential elements of lagoon fish management are the flowing brackish waters that attract the juveniles running up from the sea into the lagoon and the seawater stimulating the adults in the lagoon.

6.1.2 Fishing

The most frequently used and most effective methods for collecting fish is to attract them to the principal canal (colauro) and catch them at the fixed fishing gear (fish barrier) or by means of seine nets sieving the collecting basin. A complementary method, rather than an alternative, to this basic system is the capture of fish by means of seines (trammel and seine nets) for fin fish or fyke nets for eels. The use of nets is necessary (and can provide up to 40% of the product), when the valle is very wide or full of areas above sea level and with an irregular

floor hindering the propagation of the attraction caused by the inlet of seawater. Also inside the valle it is necessary to use other fishing gear when the weather is particularly mild: this postpones the beginning of fish migration from the valle, thus involving high risks in case of a sudden fall in temperature.

The first species caught at the fish barrier is Mugil cephalus starting its reproductive migration at the end of August.

Owing to the cooling of the valle water, sea bream and golden grey mullet reach the barrier in September; sea bass, eels and other species of grey mullet are caught later up to December. If weather conditions are good, fishing goes on in January and February as well because of tourist demand, some catches with nets are made in almost every valle during pre-Easter periods (Lent) and in spring. In some valli fishing is spread over the year in order to avoid blocking the market; this method is commonly used in almost every coastal lagoon.

The methods of fishing in the lagoons change with the absence of fish weirs or the insufficiency of the attraction to the fish weir (scarce tide range, small capacity channels, large surface lagoons, high salinity, etc.). In such conditions the principal means of fishing are often setnets such as trammel, gill and fyke nets. The fish weir is never the only fishing gear used (contrary to what happens in the valli), since the potential of lagoon hydrological management is always lower compared to that of the valle.

In lagoons fish is caught by means of fish barriers from the end of the summer up to December-January and with other fishing gear during the whole year, except in the hottest months (July-August) in some regions.

6.2 Fry stocking

Once, the principal source of fry stock was natural ascent. This explains why so much importance was given to the creation of adeguate openings in the fixed fishing gear placed at the mouths, in order to allow the fish to run up. At present the insufficient natural running up is often connected with the excessive fishing effort in the coastal belt. Already on 8 May 1304 the Republic of Venice stated that fishing of grey mullet fry could start only after 29 June, which shows that very soon the necessities of the lagoons gave rise to management policies. Now all North

Adriatic valli seed the fry fished at sea, river mouths or delta areas (Rossi, 1981a). It must be said that it was the evolution of the valle itself that hindered the natural running up, beside the evident but sometimes exaggerated decrease, which can be ascribed to sea and coastal pollution and to overfishing both professional fry catchers and fixed enclosure devices (square fishing nets, up to 15x15 m of surface). With basins enclosed by embankments, the existing sluice gates, although correctly operated, cannot assure the same permeability as that provided by open valli or those valli half embanked with long reed walls. Given that it is necessary to maintain aquaculture activities in the valle, it is not possible to subordinate the production system and yields to the unsteady and aleatory natural fry supply.

Because of the widening of the areas exploited and the recent installation of intensive breeding plants, the demand for juveniles has greatly increased. The quantity fished along the coast may have decreased, but the demand has certainly increased (Gandolfi et al., 1980, 1981). Thus most of the lagoon fish breeders are unable to meet their own needs. The negative results are evident and foreseeable: (1) lagoon fish breeders must maintain good relations with professional fry catchers, ordering the fish in time and having money available and even agreeing to pay high prices to obtain the fry; (2) prices progressively increase and the market is distorted, because of the managers' frenzied request of fry and the forms of monopoly carried out by professional fry catchers; (3) this situation affects the quality of young fish as well as they are fished more and more in advance, thus showing high death rates, being sensitive at first to the stress connected with catch, handling and transport and later to the sudden changes in temperature and salinity.

The keystone of this market should be lagoon fish breeders, who may oppose this situation by creating forms of agreements and self-government. If individual choices and uncontrolled competition prevail, lagoon fish breeding will suffer more and more and natural resources will always be managed in the worst way.

In the long run, however, the development of lagoon fish breeding doubtless depends on the availability of effective systems of artificial reproduction.

6.2.1 Species seeded

Fry stocking may start in February when Liza saliens

(leaping grey mullet) is let in; the fish is caught alone by professional fry catchers along the coast in January-February (Rossi, 1981a). This species, whose organoleptic characteristics are inferior to those of other grey mullet, is more abundant in the North Adriatic, so its seeding is not widespread.

Starting from March up to May-June the species seeded are: Sparus aurata (gilthead sea bream), Dicentrarchus labrax (sea bass), Mugil cephalus (common grey mullet), Liza ramada (thin-lipped grey mullet), Liza aurata (golden grey mullet), Chelon labrosus (thick-lipped grey mullet) and Anguilla anguilla (eel). The last one is seeded both at "glass eel" stage (rarely) and at "elver" stage (more usually) with weights of 5-20 g.

In other lagoons fry stocking is still done empirically and often consists only in collecting young fish in the sea or in the channels downstream from the sluice gates and bringing it in the lagoon. Thus it is impossible to know, even approximately, the quantity and quality introduced.

6.2.2 Seeding techniques

Young fish may be let directly into the valle basins or, better, in some areas partially isolated from the rest of the valle for some time (1-2 months up to the whole first breeding year) in order to avoid predation. Young eels and sea bass are usually seeded in the open valle, the seeding spread over different areas to assure a fair distribution. If it is necessary to protect sea breams and the most valuable grey mullet (Chelon labrosus and Mugil cephalus), the zones best fit for seeding are the peschiere which have been previously cleaned out of possible predators (above all sea bass and eels), since their depth shelters the fish from sudden changes in temperature. In this case, artificial feeding is also used in some valli to make the fish grow faster, before releasing them in the open basins, but also to stock greater quantities in narrow spaces.

Recently, traditional forms of nursery and wintering have been integrated with more advanced technologies, which involve the use of heated basins (Ravagnan, 1978), and forms of intensive pre-fattening of grey mullet (Cataudella and Monaco, 1983) and sea breams (Cataudella and Ferlin, 1984), obtaining an average 75.6% survival rate for the individuals captured in their habitat. The pre-fattened individuals were then seeded in big controlled or intensive

lagoon basins. In this way, survival rates are higher at present, even though the great survival capability of the sea bream directly seeded in large-surface basins does not encourage the extensive use of pre-fattening if one considers the high cost of labour.

6.2.3 Quantities seeded

Besides depending on market availabilities and on the economic ones of lagoon fish breeders, the quantities of young fish seeded depend upon environmental characteristics; otherwise, a lack of balance and/or an excessive burden on the fish stock and the consequent falling off of yields will be the consequence.

Once, the proportion of running up was still high and the extent of fry stocking was very small: from 500 to 1,000 fry per ha. In the 1940s Bullo says that seeding amounted to 2,500 units of fin fish per ha. In 1946 De Angelis suggested seeding 2,700-3,000 grey mullet per ha. At Valle Nuova (Rossi and Papas, 1979) an average 1,000 fry per ha (3% sea bass and 1% sea bream; the rest grey mullet) and 120 young eels (2.2 kg/ha) were seeded during the period 1950-1977. Now Boatto and Signora (1985) relate that in the valli of the Veneto lagoon the average density of fry stocking is equal to ca 3,875 fry per ha of water, of which about 80% are grey mullet, 6% sea bream, 6% sea bass and 8% young eels, equal to 3-7 kg/ha of water.

The survival rate can be directly assessed only for sea bream, as this precious species is "counted" unit by unit during the seeding and catch; moreover, its short breeding cycle (about 20 months, only one winter in the valle) gives breeders regular control. From this control it arises that the survival rate of sea bream is equal to 50-80%, unless winters are very severe.

For those species of which the quantities seeded are not known exactly (grey mullet) or which have a long breeding cycle (sea bass), the survival rate is calculated grossly, comparing the quantities seeded and the product for some years. The species most preyed upon are grey mullet (above all by sea bass and eels), so that the survival rate may also be lower than 10%. At Valle Nuova, Rossi and Papas (1979) have calculated an average 16% survival rate for grey mullet. But even sea bass seem to suffer severely from the stress of catch, handling transport and seeding besides cannibalism; it is not unusual that their survival rate is lower than 10%.

Some hints of the effects of fry stocking of eel (1 kg/ha of glass eels and 12 kg/ha of elvers weighing 6-9 g) in a Tyrrhenian lagoon are given by Ardizzone and Corsi (1985).

The survival rate of the eel is certainly proportional to its size at seeding; Rossi and Papas (1979) calculated an average 34% survival rate for small eels (5 g at seeding) and an average 2% survival rate for glass eels.

6.3 Level of fish yield and stock assesment

Stock assessment is not an easily solved problem partly because of the difficulties in finding fisheries statistics. In fact, it is not possible to check the commercialization with exactness (as we are going to see, only a part of the product is sold through official channels); moreover, breeders are not inclined to face this matter, and the product is excessively variable from year to year.

To give a revealing figure, the recurring standard production data in the valli of the Veneto lagoon is about 100 kg/ha, of which 50% are grey mullet, 30% eels, 15% sea bream and sea bass and 5% sand smelts, gobies and shrimps.

Table 4 shows the available production data (kg/ha of surface).

Studies of population dynamics have been made for different fish species or total yield in some coastal lagoons such as Fondi (Ardizzone and Rossi, 1984) with global models or, for the estimate of eel population and production, with analytic models (Beverton and Hold type) in the Adriatic (Rossi, 1979), Latium (Ardizzone and Corsi, 1985) and Sardinia (Rossi and Cannas, 1984).

7. ADMINISTRATIVE, ECONOMIC AND RESEARCH ASPECTS

7.1 Fisheries and aquaculture organization

The management of lagoon environments has greatly evolved over the years and shows the increasing importance of the public role. As regards their role, lagoons went through various phases in which at first they represented a part of the wide private coastal areas utilized for recreation purposes such as fishing and hunting to becoming environmental assets owned by public bodies, where private people are engaged one by one or in associations of various kinds, in fishery management.

Table 4. Yield per hectare in some Italian coastal lagoons

	Surface ha	Yield Kg/ha/yr	Period	Reference
Po Delta lagoons	8,556	92	1954-56	Rinaldi, 1960
Valli di Comacchio	10,000	30	1969-73	Rossi, 1979
Valle Nuova	1,900	51	1950-78	Rossi and Papas 1979
L. of Lesina	5,100	41	1970-75	Rossi and Villani, 1980
L. of Varano	7,000	28	1970-75	Rossi and Villani, 1980
Paola	375	167	1963-80	Costa and Minervini, 1982
Orbetello	2,600	142	1971-75	Regione Toscana, 1978
Cabras (Sardegna)	2,000	225	1968	Cottiglia, 1970
S. Giusta	830	689	1967-77	Cottiglia, 1981
Tortoli'	220	342	1968-77	Cottiglia, 1981
Colustrai	95	93	1968-77	Cottiglia, 1981
Calich	97	167	1972-77	Farris et al., 1978
Acquatina	45	31	1976-79	Rossi and Corbari, 1982
Grado e Marano	1,236	25-100	?	Zerbinato, 1981
		40	?	Labor. Centrale Idrobiol., 1983
Valli Venete	8,808	80-100	?	Zerbinato, 1981
		100-150	?	Labor. Centrale Idrobiol., 1983
		69	1982-84	Boatto and Signora, 1985
Burano	140	65	1981-82	Ardizzone et al. 1982
Monaci	95	284-528	1983-84	Ardizzone and Corsi, 1985
Fondi	381	50-150	1956-80	Ardizzone and Rossi, 1984

Such situations (Tab. 5) can be summed up as follows:

a) Private lagoons. At present valli belong to these lagoon areas. Fishermen are employees, variously paid and engaged full or part time.

b) Lagoons with exclusive fishing rights. This condition is derived from old permits and often has time limits. The licensee, alone or associated, owns the fish production connected with the management he performs. The fishermen may be employees or associated when the licensee is a company (cooperative society).

c) Public lagoons. There are no specific management obligations or rights. Fishermen are generally free or associated in cooperatives.

The type of lagoon ownership directly determines production strategies and fishery organization. The fishing gear used are substantially the same, but they may be employed in different ways, also according to the competitiveness among fishermen.

An interesting case is that of the valli, because of the old tradition they represent. The management of North Adriatic valli differs remarkably according to the environment, but, as a general rule, it follows some typical schemes of agricultural enterprises: since 1982, in fact, aquaculture has been classified as an agricultural - and no longer industrial - activity. The model most often followed (Boatto and Signora, 1985) is that of capitalistic ownership: the entrepreneur, either a real person or a juridical one (i.e., a company), is also the owner of the estate.

For manual operations, he hires a certain number of workers. The entrepreneur himself is rarely the manager: in some cases his intervention is limited to technical and organizational management, and his appearance is only for control purposes. More frequently, running of the estate is entrusted to a full-time administrator, especially if the concern is also connected with an agricultural activity.

Conditions of ownership, fishing rights and management vary widely for other Italian lagoons.

7.2 Valli cases

7.2.1 Administrative structure

As regards personnel, the structure may include a manager for the administration but the fundamental figure for the running of the fishing activity is the chief fisherman. He is assisted by some workers (assigned to the maintenance of the valle, to excavations, etc.) whose

Table 5. Italian coastal lagoons organization

COASTAL LAGOON	PROPERTY	FISHING RIGHTS	MANAGEMENT
Grado e Marano (Valli)	78 % private 22 % municipal	--	private and fishermen company
Laguna Veneta (Valli)	private state valli	--	private
Valle Nuova	Soc. Bonifiche Terreni Ferraresi	--	private
Valle Comacchio	comune of Comacchio	SIVALCO	municipal and regional company
Miseno	state	centro ittico tarantino campano	centro ittico tarantino campano
Fusaro	state	"	" fishermen cooperative company
Patria	state	azienda ittica lago Patria	--
Lungo	comune of Sperlonga	civic use	--
Fondi	comune of Fondi and M. S. Biagio	civic use	cooperative company + autonomous fishermen
Paola	private	--	private vallicola factory
Caprolace I Monaci I-- Fogliano I	Ministry of Agriculture and Forests	Ministry of Agriculture and Forests	Employees fishermen
Orbetello	state	comune of Orbetello	comitato gestione peschiere comunali + cooperative company
Burano	private	--	W.W.F.
S. Teodoro	private	--	private
Tortoli'	Sardinia Region	--	cooperative company
Colostrai	Sardinia Region	--	cooperative company
La Spiaggia I Maestrale I Is Prebeis I-- Foxi I	state Saline	--	cooperative company
Marceddi I S. Giovanni I-- Corru de S'Ittiri I	Sardinia Region	--	society of 5 cooperative companies
S'Ena Arrubia	Consorzio Bonifica della piana Terralba-Arborea	Fishermen co-operative company	Fishermen cooperative company
Santa Giusta	Sardinia Region	--	Fishermen cooperative company
Cabras	Sardinia Region	--	10 Fishermen cooperative + autonomous fishermen
Mistras	Cooperativa Molluschicoltori	--	Cooperativa Molluschicoltori
Is Benas	Sardinia Region	--	Fishermen cooperative
Calich	Sardinia Region Ente Trasformazione Fondiaria e Agraria	--	Fishermen cooperative
Pilo	Private	--	--

number varies according to the size of the valle and to the level of organization achieved, and by at least one guard. The latter is indispensable as thefts and poaching represent a big problem throughout the lagoon areas. Finally, there is a biologist for some valli with intensive rearing sectors.

The workers enjoy facilities and are issued with protective clothing (boots, raincoats, overalls, gloves). The peculiarities of this activity require a remarkable polyvalence in the worker, since it is not easy to operate a homogeneous distribution of the work load in the course of the season and an actual subdivision of tasks among the workers. Intense activity periods occur in spring (stocking) and in autumn (fishing): during the off-season the main activity is the repair of structures and tools.

In the Upper Adriatic valli, Boatto and Signora (1985) calculated an average of 1.26 workers per 100 ha, but this ratio varies greatly, also according to the surface of the concern. During the period of autumn fishing, a certain number of temporary workers are taken on in addition to the permanent ones.

Very few data and precise information are available regarding the economic results of valle enterprises. In this connection we shall refer to the works of Donati (1983) and Boatto and Signora (1985).

7.2.2 Estate value

The market value of valle surfaces derives from various factors, among which the most important are: a) the location, b) the conformation and the total area of the enterprise c) the general condition of the structures (embankments, fish barriers, buildings, the conditions of canals, fish pools, etc.), d) fresh water availability.

The value of a valle is, however, difficult to ascertain: from recent sales (1985), it seems that the prices fluctuate between 7 and 15 million lire per hectare.

7.2.3 Yield value and income

To calculate the income of valle enterprises it is necessary to establish some parameters.

In this context we shall consider only the net operating income, without further analysis for which we

refer the reader to the already mentioned publication by Boatto and Signora (1985).

The values indicated refer to a typical concern, with average parameters such as those found for the valli in the Venetian region. The first information required is the amount of gross estimated sales, from which sundry expenses, maintenance costs, taxes and workers salaries must be deducted.

7.2.3.1 Markets

The fishing technique used in the valli causes a maximum productivity peak in October-December when 70-80 % of the total production is reaped. As a consequence, problems of distribution or of low profitability arise due to the direct introduction of the product onto the market. The necessity of spreading the fishing operations - and therefore the selling operations - over time is increasingly felt. Attempts to overcome the problem consist in stocking for a few days in cold storage or, when possible in keeping the fish alive in wintering fish pools. The problem does not arise for eels which can be kept for months in suitable wooden, wicker or plastic containers hanging from poles and placed in the water. This happens as a rule because the marketing of eels reaches its maximum peak in December when prices are highest due to the high demand, especially from southern Italian dealers. Concerning other fish (grey mullet, sea bream, sea bass), breeders as a rule introduce the product into the market as soon as it is caught.

The marketing channels and the systems of sales vary considerably.

In the case of eels, only a small part (10-20 %) is distributed through fish markets. Their price shows instability and fluctuations even independently of the production curve (Gatto et al, 1979). Most eels (up to 80 %) are sold to local retailers or hotel keepers, but above all to wholesalers of southern Italy during the Christmas period. Eels are traded directly at the fishing sites with a double advantage: the price is higher than that which can be obtained at the fish markets and both risks and transportation costs are completely eliminated.

Smaller quantities are supplied to local or foreign industries (for pickling or smoking) because of the low prices. Only in the Valli of Comacchio, equipped with their own transformation plant, around 10 t/year are pickled.

Also for the other fish there are at least three open marketing channels: fish markets (up to 50 % of the product), local retailers and hotel keepers and local or southern Italian wholesalers.

7.2.3.2 Calculation of the net operating income

Table 6 shows the structural features of a hypothetical valle in the Veneto region.

Table 6. Structural features of a typical concern in the Veneto Valli (from Boatto and Signora, 1985).

Surface:	367 ha
Equipment:	1 excavator on tracks
	1 floating excavator
	1 van
	5 rowboats
Permanent workers:	4
Temporary workers:	2, for 60 working days

The average lagoon yield is 69 kg/ha corresponding to a gross sales (GS) of lire 826,500 per ha.

Among sundry expenses (SE) are considered the seeding (lire 309,000/ha, lagoon average), the costs for miscellaneous services (2 % of GS), electricity costs (2 % of GS) and the overheads (2 % of GS). The amortization share (A) includes amortization of restoration and maintenance costs of estate capital and tools (for details, refer to Donati, 1983). Taxes (T) have been calculated as 1 % of GS, wages (W) on the basis of current Italian tariffs: 18 million lire a year for permanent workers, 40,000 lire/day for temporary workers and 3 % of GS for a part time administrator.

The calculation of the net operating income is shown in Table 7, from which we obtain an income of approximately 62 million lire, equal to 20 % of GS. It can be seen that the most expensive items are seeding and wages.

Table 7. Calculation of the net operating income (from Boatto and Signora, 1985)

	Lire (* 1000)	%
GS	303,000	100
SE	131,180	43,3
A	23,640	7,8
T	3,030	1,0
W	83,490	28,5
Net operating income	61,660	20,3

7.3 Differences between valli and coastal lagoons

The environmental differences between valli and coastal lagoons have been pointed out in Chapter 3 showing that the first are run with artificial fry stocking, active hydraulic management and most of the fishing at the fish barriers, while the second have natural fry stocking, artisanal fisheries inside the barriers and often lack hydraulic management (D'Ancona, 1955). De Angelis (1955) compares the balance of a coastal lagoon in Sardinia with that of an Adriatic valle for the same year (Table 8).

Table 8. Comparison between the balance of a lagoon and a valle

	Lagoon %	Valle %
Fry seeding	/	17.4
Permanent and temporary workers	60	20.4
Materials	2.4	13.3
Maintenance	3.1	15.2
General expenses	17.5	16.7
Total costs	83	83
Net income	17	17
	100%	100%

These figures show a high incidence in the costs of workers (fishermen) for coastal lagoons because fishing in this environment needs many operators while the valle has important costs for artificial fry stocking.

General expenses are similar for both valle and lagoons while for the valle costs for materials and maintenance are higher because of a more complex management structure.

7.4 Scientific research

Italian lagoon management has always interested researchers. There is a plentiful national bibliography on lagoon ecology; the recent development of sea aquaculture has stirred up the interest of public bodies, researchers and private entrepreneurs, who aim at carrying out basic and applied research on the problems of lagoon management.

This interest is confirmed by the current research programmes, the most important of which are mentioned here below.

- After an aquaculture programme which was partially directed to those species fit for the development of fishery and aquaculture in lagoons ended in 1981, the National Council for Scientific Research (CNR) has started a line of research within the plan "Improvement of Agriculture Production (IPRA)" aimed at developing aquaculture, involving the aspects of lagoon ecology and studies on eels. Recently a strategic plan has been designed for the reproduction and breeding of lagoon sea species. In 1968 the CNR created the Institute for the Biological Exploitation of Lagoons, located near the lagoon of Lesina, for research activities connected with resource management and with the development of aquaculture in Italian lagoons.

- Promulgating Law 41/82, the Ministry of the Merchant Marine has financed a three-year research programme and an aquaculture programme for the capture, along the whole national coast, of those juvenile sea species that are particularly important for lagoon aquaculture. Another three-year activity is foreseen. The same law has envisaged the establishment of an institute for research on fishing and aquaculture.

- Through its Central Laboratory of Hydrobiology and promulgating Law 984, the Ministry of Agriculture and

Forestry has financed a project aimed at developing national aquaculture divided into two subplans, one of which is directed to the breeding of euryhaline sea species and to lagoon management.

- The Ministry of Public Education has financed research carried out by universities on lagoon ecology and on the specific aspects of vegetable and animal species of lagoon environments.

- Regional, provincial and town administrations have often financed research on lagoon environments, in order to extend the cognitive bases for development projects.

- The National Electricity Board (ENEL) and the National Alternative Energy Board (ENEA) have contributed to the development of aquaculture in lagoon environments through research on the production of fry of those species having a particular economic importance.

- Scientific associations, such as the Italian Society of Sea Biology (SIBM), the Italian Zoology Union (UZI) and the Italian Society of Ecology (SITE) have dedicated symposiums and seminars to production management activities of lagoon environments, fostering collaboration between Italian and foreign researchers.

- Private companies have often financed and promoted autonomous research activities and have favoured collaboration between private people and public researchers, in order to match the demand and supply of research in this field.

The results of most of this research are not transferred into the field through specific bodies. However, local researchers working in production plants carry out extension activities. The participation of researchers and producers' and workers' representatives on the technical boards of the ministries financing applied research guarantees the quality of the research and the democratic utilization of the public means of the research. As a rule, the administration pays particular attention to the problems of lagoons as far as environment rehabilitation, fishing and aquaculture are concerned.

8. CASE STUDIES

To give a complete picture of the condition of Italian lagoon management, there follows a series of short analyses of lagoons which are representative of (a)

geographical site (Adriatic - Tyrrhenian); (b) type of management (with/without fish barriers); (c) kind of ownership (public/private).

The lagoons have been chosen in different areas, taking into account primarily those showing a series of historical data concerning captures correlate with different ways of management. Thus it is possible to give also a developing picture compared to the present condition, underlining the efficacy of the choices made in the various management areas.

8.1 Valli di Comacchio

They are a group of 3 brackishwater basins with a total area of about 10,000 ha, an average depth of about 1 m and connected to the Adriatic by a system of canals more than 28 km long. Fresh water, coming from the Reno River, reaches the basins through siphons. Since 1975 an intensive eel breeding of about 32 ha has been functioning; it takes water from the valli and discharges it back to them.

The valli belong to the town of Comacchio and are managed by a public company, in which the town itself and the region have a share. The company is composed of 110 people; 12 have managerial, technical and administrative duties, performed by the technical office and the data-processing centre, about 60 are workmen and the remaining people are guardians.

The production plants of the Valli of Comacchio are typical of extensive and intensive breeding. Among the former, there are 4 fishing stations equipped with fish barriers, buildings for the guardians and stores for fishing gear and boats. As a rule, there is no fishing inside the Valli. The company has two refrigerator trucks used to carry the fish to the market. An important part of the company is the factory for the pickling of eels and sand smelts. The intensive breeding section is fitted with a research lab equipped for water chemistry analyses and control of product quality.

Fishery management is of the traditional kind. Since the ascent of natural fry is hindered (canals filled up with earth, sport fishing in water-conducting canals), fry stocking is usually adopted. Official data regarding fish production have been available since 1781 (Fig. 21). The average yield per hectare (span of time 1781-1982) is equal to 16.4 $\pm$ 6.5, of which 14.3 $\pm$ 5.8 are eels, representing

about 87% of the total. Variations are mostly due to environmental problems. The drop of 1822-60 was due to hypersalinity and freezing of the valli, beside the ruinous breaches of the Reno's embankments. High mortality caused by cold and hypersalinity was also the reason for the drops that occurred around 1880 and during the 1925-30 period. The high yield of 1964-67 was the consequence of re-stocking in the remaining valli and of the young fish coming from the improvement of the Valli of Mezzano. The recent drop is due to the inlet canals progressively becoming blocked, to the decrease in fry ascent, to the anoxic crisis caused by phytoplankton blooms and to the cold.

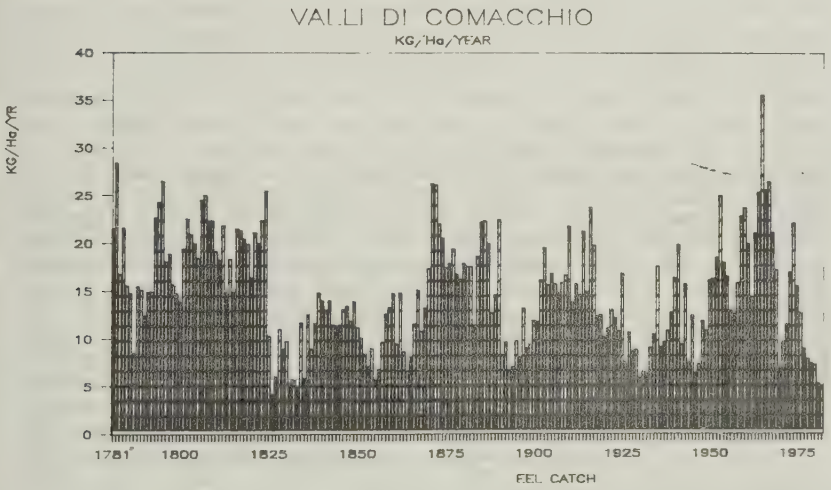

Figure 21. Fish yield in the Valli of Comacchio

8.2 Valle Nuova

Valle Nuova is a complex of 3 valli of about 1,900 ha, near the Valli of Comacchio. Water exchanges with the

sea are assured by a canal that opens near one of the outlets of the Po River, provided with a fish barrier made of plastic rods and sluice gates. On the southern side of the Po outlet, fresh water is pumped into the valle, if needed. The average depth is about 50 cm; there are many surrounding canals and deeper fish ponds for fish wintering. Annual average salinity has increased to about 22‰. Valle Nuova belongs to the Societa` Bonifica Terreni Ferrarese of Rome, which manages it through a production director. The staff is composed of a valle head, three full-time workmen, seasonal workers during fishing periods, and two guards.

The company has two buildings for the guards and stores for the nets and the row boats or the outboards. The fish barrier is fixed and made of periodically renewed plastic rods, secured to wooden stakes.

The fishery management adopted is typical for north Adriatic valli. In spring, fry ascent is encouraged (open sluice gates) and supplemented by stocking fry fished outside by local fishermen. On average, during the period 1950-78, about 2.2 kg of small eels, weighing 2 g, and about 1,000 newly hatched fish were stocked per hectare each year (200 leaping grey mullet and thin-lipped grey mullet, 180 common grey mullet, 260 golden grey mullet, 120 thick-lipped grey mullet, 30 sea bass and fewer than 10 sea bream). In autumn, fishing is mostly carried out by means of the fish barrier. Too small fish are let into special fish ponds for wintering. Fish barrier captures are supplemented with nets placed in the downstream canals and with fixed fishing gear (winged fyke nets) in those areas that are farther from the fish barrier. The trend of the catches is shown in Figure 22. In the period taken into account the yield averaged 51 kg/ha, with eels representing about 47% of the fishery, grey mullet 46%, and atherines the remaining 7%. The variations in yield were very large. The drop of the period 1967-75 was mostly due to the presence of the ectoparasite Argulus giordanii and to the flooding that struck the whole coastal area in 1966, destroying the enclosing embankments. Furthermore, the drop in the yield was caused by the decrease in fry stocking quantities: in 1966-74 stocking decreased by nearly 40% compared to the period 1950-66. The recent recovery seems to be connected to the increases in fry stocking, which have regained the level of the 1950s.

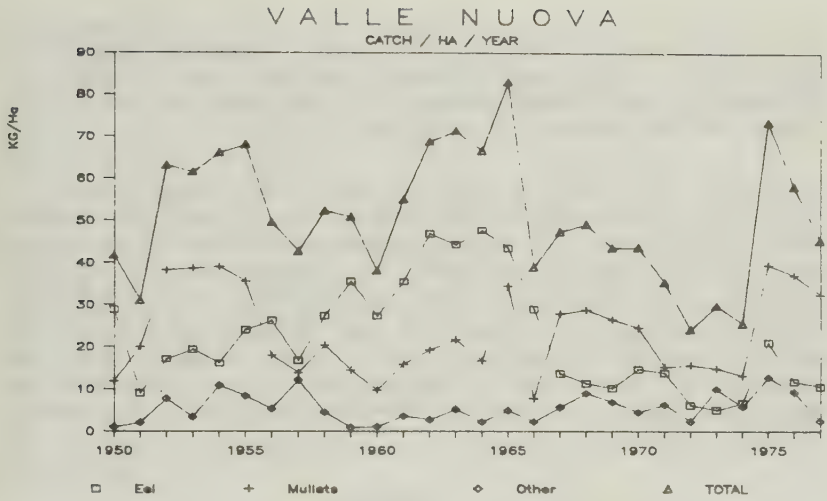

Figure 22. Fish yield in the Valle Nuova

8.3 Lesina

The lagoon of Lesina is located in the southern Adriatic on the Gargano Promontory. It measures 5,100 ha, with a depth of about 0.6 m. Two canals assure water exchanges with the sea. The lagoon extent and the average depth keep the sea influence limited.

At first, the lake of Lesina was part of a fiefdom (1306). It was acquired by a private company in 1892, and starting in 1935, the fishing rights were granted to the towns of Lesina and Sannicandro. At present three cooperatives manage the lake with a total of 135 fishermen. The number of people employed has decreased: 292 (1953-57), 230 (1971-76), 135 (1984).

The principal fishing gear used is the paranza, a system of leader nets barring the lake from one shore to the other (from 1 Sept. to 31 Jan.) each with 350-500 fyke nets (meshsize 6 mm). During the other months no more than two thirds of the lake can be closed. At present there are about 60 leader nets in all. Every year the fishing areas are assigned by lot. Moreover, gill nets and movable fish barriers are used at the outlets. Fry stocking has been carried out since 1978 because of the decrease in yields.

In the 1950s the catch was divided as follows: 37.9% eels, 17.6% sand smelts, 42.5% grey mullet, 0.4% sea bass, 0.3% sea bream, 1.3% other species. Now it is the following: 22.8% eels, 43.4 sand smelts, 29.4 grey mullet, 0.5 sea bass, 2.7 sea bream, 1.2 other species.

The production trend has gradually decreased (Fig. 23) showing a partial recovery during the 1980s thanks to fry stocking. The modification is not only quantitative but also qualitative, as eels and grey mullet were reduced and sand smelts, suffering less from the selectivity of the fishing gear and reproducing in the lake, were increased (Lumare and Villani, 1987). This trend is due to the fishing methods adopted (barring of the lake from shore to shore), which make it possible to catch most of the fish present in the lagoon yearly without any selection of meshsize, and partially to the decrease of the fry ascent from the sea.

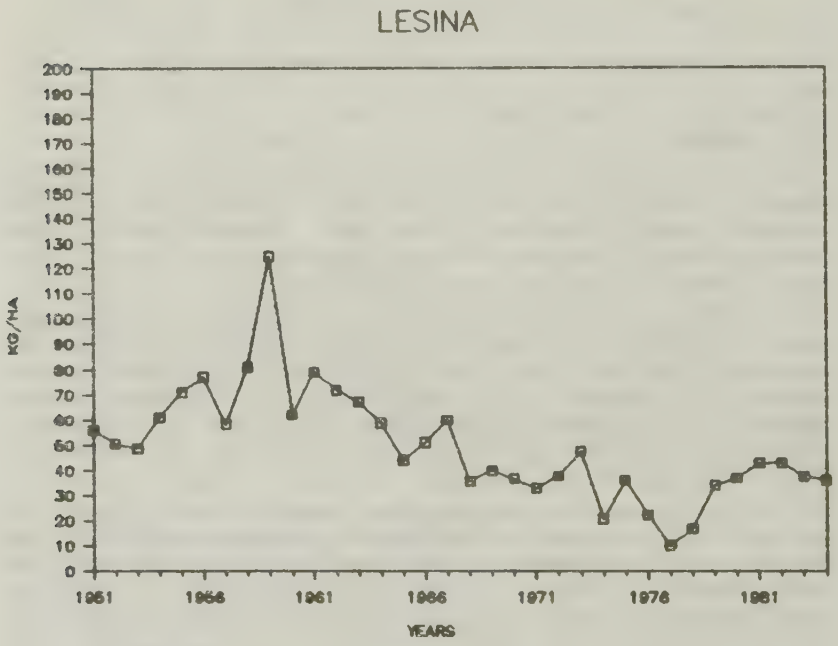

Figure 23. Fish yield in the lagoon of Lesina

8.4 Orbetello

The lagoon of Orbetello has a total area of 2,700 ha and an average depth of 1 m. It is divided into two basins (western and eastern) connected with the sea through three canals. The salinity ranges from 27.7 to 47.4‰.

The lagoon is managed according to the exclusive fishing rights given to the town of Orbetello in 1882. However, fishing activities had been controlled by the town since the XVIth century. Since 1961, the fishery has been managed by the Comitato Gestione Peschiere Comunali and by a cooperative of fishermen of about 60 members, who administer the stores, the offices, the guardianship and the fishing at the fish barrier and in the lagoon. The three stations of fixed fishing at the fish barrier are located in the canals connected with the sea and provide about one third of the total catch; the other two thirds are obtained with fyke nets and gill nets in the internal part of lagoon.

Relations between the cooperative and the town (Comune) are governed as follows: 30 % of up to 100 million lire collected on the draught by the cooperative society is due to the Comune; over 100 million lire, 50% (Regione Toscana, 1978).

The trend of the catch has progressively increased (Fig. 24), which is connected to the fact that management has always improved beginning in 1900 to today (Del Rosso, 1905; De Angelis, 1946; Regione Toscana, 1978). In particular, modern fish barriers were built, the bottom was dredged and seawater was pumped during critical periods.

The increase in eutrophization might have had a positive part in production improvement (Kapetsky, 1984), but it has surely affected periodical dystrophic crises involving high mortality. During 1971-82, the catch averages 170 kg/ha (Regione Toscana. 1985). In the period 1971-75 the average percentage composition was the following: 48.8% eels, 36.7% grey mullet, 10% sea bass, 0.5% sea bream and 4% other species (Regione Toscana, 1978). Artificial fry stocking is rather limited and scarcely important for the yield.

8.5 Tortoli`

Tortoli` is a lagoon of 259 ha with an average depth of about 1 m and a mean salinity similar to that of the sea.

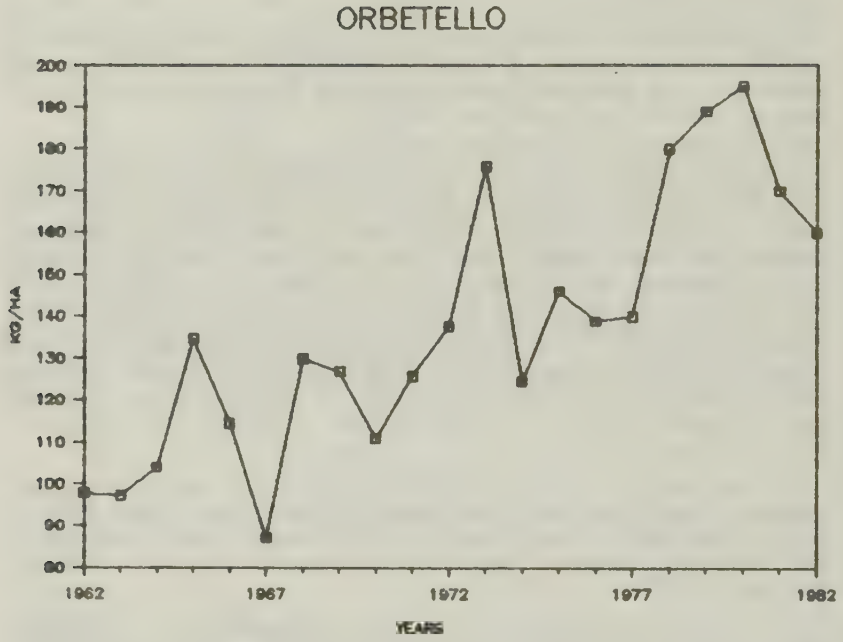

Figure 24. Fish yield in the lagoon of Orbetello

There are two outlets to the sea, one placed above the canal Becasara (240x40x7 m), provided with modern concrete fish barriers, the other above a canal of 220x20x50x1.5 m, equipped with a fish barrier made of PVC rods. Fresh water is assured by a by-pass above the Rio Girasole, flowing north of the pool.

Tortoli` belongs to the Sardinia region, and the fishermen cooperative of Arbatax, composed of 51 members and 16 employees, has the concession of the lagoon. Besides the staff, only ten of the associates are real fishermen. The lagoon is equipped with stores, boats and fishing nets. Fishing is mostly carried out by means of fish barrier; inside the lagoon there are 180 fyke nets functioning all the year round, even during the period of the fry entrance. From mid-October up to January the trammel net is used as well.

Figure 25 shows the fishing data available from 1957 to 1978. The yearly catch averaged 352 kg/ha. Some facts particularly affected the yields. In 1959 the link with the canal Girasole was closed. The yield was negatively affected by that: while in 1957-59 the average catch was equal to 495 kg/ha, in 1960-64 the yield dropped to 317 kg/ha. In 1964 a canal conveying the fry into the lagoon was closed, and in 1965-68 production decreased to 261

kg/ha. Since 1968 fry has beeen captured in surronding coastal areas and stocked in the lagoon: yield increased to 382 kg/ha in the period 1969-71. Later, this form of fry fishing became illegal and was given up: in 1972-75 the yields again dropped to 308 kg/ha. In the past three years the yield (415 kg/ha) has risen again, due mostly to the production of mussels.

In former years the catch was composed of grey mullet (over 50 % of the total), eels (30 %), sea bream and sea bass (5 %). and other species (15 %).

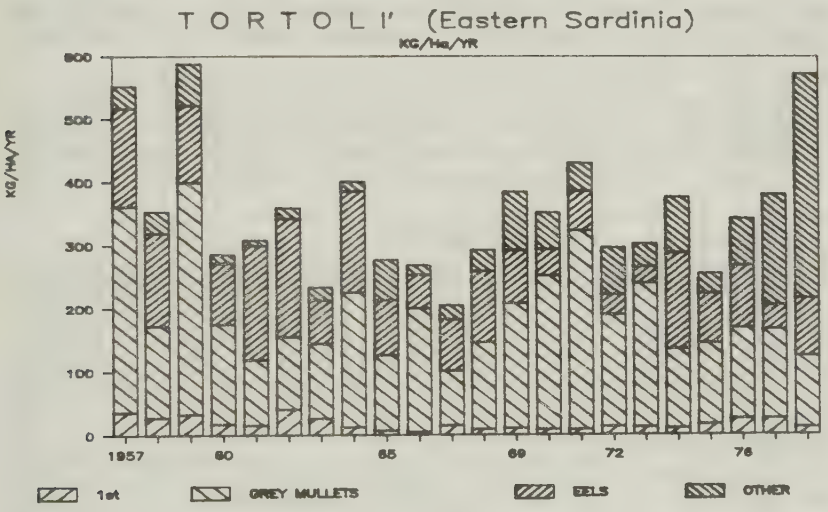

Figure 25. Fish yield in the lagoon of Tortoli

8.6 Fondi

It has an area of 381 ha and an average depth of 9 m (max 21 m). It is linked with the sea by two canals, measuring 2.4-2.8 km in length. The salinity ranges from 3 to 13 ‰ at the surface and 10 to 22 ‰ in deeper layers. The morphological configuration and the differences in the salinity give rise to a permanent stratification with water anoxia under 2-4 m depth.

The lake is public and is used by those residing in the towns of Fondi and Monte San Biagio.

At present the people working on the lake are fishermen associated in a cooperative and free fishermen. The number of fishermen in the cooperative has dwindled, while part-time free fishermen with another job have increased.

The shores of the lake are steep and this limits the use of fishing gear such as complex structures of fyke nets. The principal fishing gear used are single fish traps placed along the shores for eels and surrounding nets for grey mullet. The canals are not equipped with fish barriers.

The yields are very unstable due to the absence of fish barriers, to the anoxic state of the lake leading to high mortality and escape of fish, and to the irregular fishing effort. All that results in high variability in the trend of the catches by the fishermen of the cooperative in the past 25 years (Fig. 26). However the catches per unit of effort show a regularly increasing trend during the period examined (Ardizzone and Rossi, 1984).

In those periods in which the fishing effort is greater and more regular, catches are composed as follows: grey mullet, 42.2 %; eels, 27.7 %; sea bass, 8.1 %; other species, 21.9 % (1957-59); grey mullet, 76 %; eels, 10.4 %; sea bass, 0.8 %; other species, 12.8 % (1967-71).

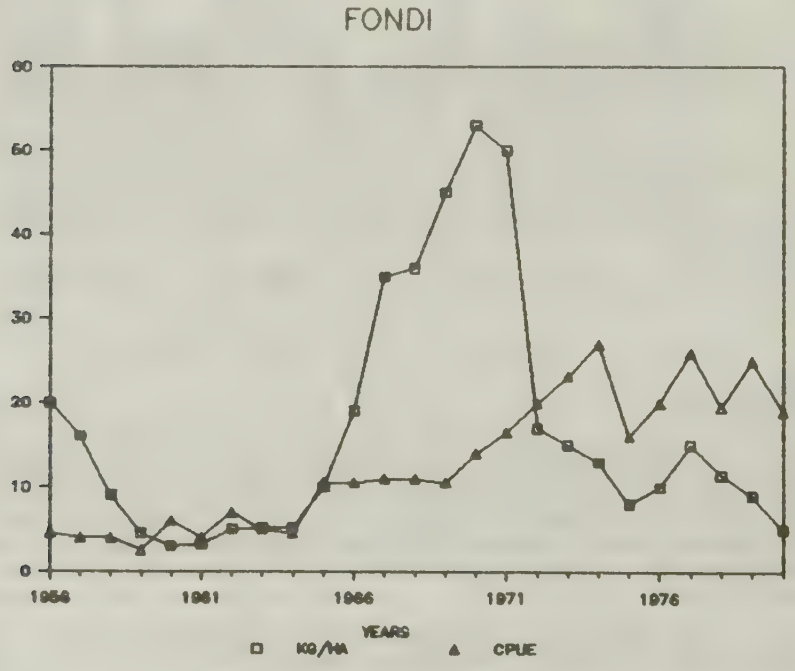

Figure 26. Fish yield and catch per unit effort in the lagoon of Fondi.

8.7 Burano

It is in the Tyrrhenian, a few kilometres south of the lagoon of Orbetello. It covers 140 ha, with an average depth of 0.8 m. It is connected to the sea through an outlet that tends to silt up with the sediment brought by two tributaries. Salinity varies between 27.7 and 47.7 ‰.

The lake belongs to an agricultural company. Since some years, the World Wildlife Fund (WWF) has been managing a fauna oasis for aquatic birdlife, and the fishery has been considered a marginal activity. There are two part-time fishermen and the fishing structures (stores, fishing gears etc.) are in bad condition. There are no fish barriers in the canal connected to the sea.

Fishing takes place from October to May with fyke nets for eels and trammel nets for other species. There is no fry stocking and the natural running up is hindered almost all the year round, because of silting up (Cognetti et al., 1978; Ardizzone, 1982).

In the past few years the yield of the lake equaled 60 kg/ha, which is way below the Tyrrhenian average. This is due to bad management of the aquatic environment, which paradoxically is in an area of fauna preservation. In fact, the reasons for such low yields are: the periodically closed outlet to the sea and, therefore, the poor water exchange, the insufficient fry ascent, the silting up of some parts of the lake and the lack of fish barriers.

In the nearby lagoon of Orbetello, as in other Tyrrhenian lagoons, careful fishing management with proper interventions for environmental preservation lead to a fish production that is more than twice as much, and increase the value of naturalistic role (Ardizzone, 1984).

9. FISHERIES IN RELATION TO COASTAL ZONE MANAGEMENT

9.1 The lagoon in the coastal system

In a highly populated and developed nation with peninsular orography such as Italy, the coastline represents a focal point for various interests.

It is in fact the centre of economic interests connected, for example, with tourism and the exploitation of biological resources (agriculture, breeding, fishing), but it is also the seat of continental water discharges originating from domestic and industrial uses.

Considering the lack of national coordinated planning, coastal lagoons in their interface position between water and land are particularly subject to aggression from such interests. These normally develop in direct relation to the income level that can be generated: fishing and aquaculture as well as qualitative conservation of very important environments, even from a naturalistic point of view, often receive only marginal attention.

The environmental protection now existing for the Italian lagoon areas can be considered as deriving from Act 1497 of 29 June 1939 on landscape bonds, from Act 3267 of 30 December 1973 on hydrogeologic bonds, and from the international Ramsar convention on wetlands (D.P.R., 448 of 13 March 1976). Many areas are also part of existing parks or oases and of proposals for others (Circeo National Park, Burano and Orbetello Oasis, Po Delta Park Project).

Any discussion about the overlapping of interests and exploitations in lagoon areas is naturally very complex but dealing with the main aspects that could interact with fishing and acquaculture management, four principal points can be underline:

i) various and uncontrolled fishing efforts (sports fishing, trawler fishing, small-scale coast and lagoon fishing) interacting on unitary fish stocks (sea-lagoon)

ii) introduction of polluting waters often with high eutrophyzing loads

iii) tourism and urban development

iv) naturalistic needs with preservation of biotopes and protection of species of particular interest.

9.2 Interactions among fisheries

This aspect is particularly evident in those lagoons where fish recruitment is still mostly tied to the natural ascent from the sea.

Environments such as the North Adriatic valli being dependent for their production on seeding by man are now in a situation of relative autonomy from natural stocks. For the other lagoons, it is fundamental to preserve the renewable fish resources through accurate control of the exploitation state of the various stocks. Only recently, however, has a series of studies for the assessment of such

fish resources been started. Up to now the regulations of various types of fishing effort have no effect. This condition is particularly serious along the coastal belt (inside 3 miles) where trawler fishing operates illegally in conflict with small-scale coastal fishing, sports fishing and, indirectly, lagoon fishing.

Thus, numerous fishing categories operate on the same stock completely independently and without any control. For example, the following types of fishing are practised on species such as sea bass and sea bream:

a) small-scale coastal fishing with gill nets, trammel nets, long lines, small purse seine

b) coastal trawling inside three miles

c) sports fishing (lines and diving)

d) fry fishing along the shores, at the mouth and in the canals

e) lagoon fishing

With so many different and intensive types of fishing, overfishing conditions are inevitable and so is the progressive reduction of fish recruitment in lagoons. Hence, the necessity of artificial seeding for those lagoons situated in coastal areas that are most heavily exploited. From this point of view, the Italian lagoons in the worst conditions are those of the Adriatic and those of Latium and Tuscany for the Tyrrhenian while Sardinia is still in relatively good condition.

Fish restocking and defensive actions to eliminate trawler fishing inside three mile zone have been effected through artificial reefs in some Italian areas (Liguria, Latium, Sicily, Marche), and they could create interesting reproduction oases in sea areas opposite coastal lagoons, to restore the overexploited stocks to their original levels (Ardizzone and Bombace, 1983; Ardizzone, 1984).

9.3 Organic pollution

Pollution has been one of the most delicate subjects in the past few years. The ever greater number of urban settlements, the development of intensive agricultural activities and the presence of industries along the coastal belt has increased the polluting load of discharge waters and therefore rivers and canals flowing into the lagoons.

Critical conditions are reported for many Italian lagoons (Giordani-Soika and Perin, 1974; Regione Toscana, 1978; Perdicaro et al.,1980; Cottiglia, 1981; Ardizzone, 1984; Regione Toscana, 1985). Increased trophic loads combined with a lack of interventions for a correct control of the waters and therefore with insufficient water exchange result in summer dystrophy problem often causing heavy mass mortality.

Many hydraulic plans realized decades ago in completely different conditions of population density and land use need complete restructuring. Thus, for example, the utilization of lagoons as fill basins for reclaimed areas where fertilizing levels of cultivated grounds reach unbearable loads for waters already so rich in nutrients as lagoon waters.

9.4 Tourism and urban development

Among the numerous-income producing activities on the Italian coastline, tourism and its relative urban development are surely the most important competitors with fishing and aquaculture activities.

Villages, hotels, camping sites and tourist harbours are often prefered choices in the context of territorial planning still tied to economic interests of a traditional type. Yet another reason is the ancient traditions of tourist development of Italian coasts. We are dealing, in fact, with a consolidation of development trends started long ago more than with novel choices for new environments. Many anthropic alterations should therefore be considered as part of the ecosystem and treated as such in the best possible manner. The aim should be that of checking and controlling the impact on the environment rather than promoting useless efforts to reach unattainable changes of the existing reality.

It has been and still is possible to make some choices thanks to intact environment conditions with the creation in lagoon areas of natural oases. The hunting carried out along coastal areas because of the abundance of aquatic birds wintering in Italian lagoons, swamps and marshes (Tab. 9) is now gradually reducing. The birth of conservation and protection plans gave rise to new forms of utilization of these natural resources (i.e., Burano and Orbetello) and to new types of tourism with ever increasing succes (routes for bird watching, instruction camps, census observation posts, etc.). The importance of these recreational trends should be assessed in economic terms

compared to overall environmental modification for simple acquisition of physical space. The example of lagoons promoted to tourist harbours represents one of the most frequent cases in this direction.

9.5 Naturalistic need

Naturalistic aims could be, at the present time, the best ally for a balanced development of activities related to lagoon fishing production. Nevertheless, this link does not occur often because of conflicting interests which have a tendency to arise between conservation and production aims. In actual fact, a type of management covering both aspects is not only attainable but could also offer reciprocal advantages.

The role of lagoon areas as naturalistic assets of great importance does not need to be emphasized: most protection bonds presently enforced along the Italian coasts concern these areas. But the "discovery" of the environmental value is relatively recent as compared to that of the production value. This implies that most coastal lagoons started to be altered in ancient times in function of fishing management requirements. These modified environments need active control since, to their natural typical instability, are added modifications requiring managemnt (for example the opening or closing of the sluice gates for hydraulic control). The deterioration of bordering environmental conditions recently increased the need for accurate human management. In these conditions the productive and therefore active management of coastal lagoons means optimal conservation because no production can exist in a degraded environment. In fact, a badly run or abandoned lagoon is normally a lagoon with a small production and, at the same time, an environmental asset with a reduced number of species and therefore of scarce naturalistic interest.

Equally important is the advantage deriving from the protection of such environmental value for production purposes. In fact, only thanks to the existence of severe environment bonds is it possible to allow the maintenance of activities that are marginal or economically scarcely competitive compared to other forms of territorial use.

Table 9. Aquatic birds wintering in Italy in 1978

	Lombardy	Friuli Julia	V. Venetia	Emilia	Tuscany	Latium	Apulia	Sicily	Sardinia	Abruzzo	Total
Surface (hectares)	1.386	12.087	23.875	21.650	2.962	7.248	15.516	430	4.863	353	90.370
Anas platyrhynchos	833	525	6.361	3.196	1.143	1.017	4.918	19	820	358	19.190
Anas crecca	226	3.450	3.771	5.710	2.327	3.338	2.610	930	1.310	29	23.791
Anas querquedula	---	630	---	---	---	---	---	---	---	---	630
Anas strepera	1	10	542	362	40	186	1.557	10	9	---	2.717
Anas penelope	8	385	1.307	2.430	2.952	3.075	9.826	325	3.220	---	23.528
Anas acuta	2	495	2.033	179	1.113	373	1.719	220	455	---	6.589
Anas clypeata	---	168	1.116	1.134	953	544	5.527	68	1.510	---	11.020
Anas angustirostris	---	---	---	---	---	---	1	---	---	---	1
Netta rufina	---	---	---	1	---	12	2	---	---	---	18
Aythya marila	---	---	70	---	---	---	2	---	---	---	72
Aythya fuligula	5	49	1.375	8.922	109	635	19	---	12	---	11.126
Aythya ferina	12	97	3.418	25.069	600	2.809	665	59	400	---	33.129
Aythya nyroca	---	---	---	2	---	---	267	---	---	---	269
Bucephala clangula	---	1.155	153	71	---	5	2	---	---	---	1.386
Clangula hyemalis	---	---	---	---	---	---	5	---	---	---	5
Melanitta fusca	---	10	---	---	---	---	6	---	---	---	16
Melanitta nigra	---	---	---	---	---	---	120	---	---	---	120
Somateria mollissima	---	---	---	---	---	10	---	---	---	---	10
Mergus serrator	---	1.740	174	---	13	10	1	1	---	---	1.939
Mergus merganser	---	---	12	---	---	---	---	---	---	---	12
Mergus albellus	---	1	---	---	---	---	3	---	---	---	4
Tadorna tadorna	---	---	---	3	8	30	22	150	106	---	319
Tadorna ferruginea	---	---	---	---	---	---	---	---	---	---	---
Oxyura leucocephala	---	---	---	---	---	---	2	---	---	---	2
Cygnus olor	17	---	---	---	---	---	12	---	---	---	29
Cygnus cygnus	---	---	---	1	---	---	6	---	---	---	7
Cygnus bewickii	---	---	---	---	---	---	4	---	---	---	4
Fulica atra	2.000	12.630	57.111	72.550	7.947	22.775	19.753	170	1.950	---	196.886
Unidentified duck	---	1	400	---	---	1	1	---	320	12	735

10. CONNECTIONS WITH OTHER AQUACULTURE ACTIVITIES

In the evolution of modern Italian aquaculture, the traditional experience of fish rearing in *valli* and of productive management of lagoon environments play a decisive role (Bullo, 1891).

This connection is shown by the fact that the first demand of artificially produced seed of euryaline species for aquaculture (*Dicentrarchus labrax*, *Sparus aurata*) arose out of the North Adriatic *valli* aquaculture itself.

The necessity for new kinds of production in the *valli* was due to various factors, the most significant of which are summarized below:

1) The modified ecological conditions, especially in the quality of both fresh and salt waters. Without control of fresh-salt water balances, most management "instruments" will fail.

2) The reduced quantity of available seed to restock the *valli* especially for the species of greater economic value and consequent high costs of the available seed.

3) The increase in salaries and maintenance costs, as well as the attraction of more remunerative employment in agriculture and industry and of better living conditions.

4) The conflicts between public administration and the owners of *valli*, for example, to obtain authorization for dredging, water intakes, and other indispensable operations.

5) The low income per surface unit, especially in those environments more subject to the above negative impacts.

These and other causes have created the need for a renewing process in North Adriatic *valli* through the introduction of new forms of aquaculture (Ravagnan, 1978).

10.1 *Seed production in hatcheries*

In recent years in Italy, as in France and the U.K., a series of results was collected on the reproduction of species suitable for aquaculture and therefore on seed production.

In Italy, after the first experiences on grey mullet (Gandolfi and Orsini, 1968), most efforts were directed to the production of sea bass (Dicentrarchus labrax) seed (Arcarese et al., 1972; Alessio et al., 1973; Ravagnan, 1978a) in intensive plants.

At the same time but with less interesting results, studies were started on the reproduction of sea bream (Sparus aurata) (Lumare and Villani, 1971; Alessio, 1975; Alessio et al., 1975; Freddi et al., 1981; Mazzola and Rallo, 1981). Among other species, in particular the sole was the subject of research (Brasola, 1974). At present Italy counts about 15 centres using more or less sophisticated technologies for the production of sea bass seed for a total yield of 2 million head. The hatcheries productive capacity for sea bream is very limited and not constant. The total production is a few hundred thousand head.

There is also a production capacity for shrimp Penaeus japonicus post-larvae (Lumare, 1981): introduced in Italy in 1979, these are produced mostly in the experimental hatchery of the CNR. The maximum production achieved was 2 million post-larvae P.30. On a private level, some hatcheries are also making attempts with overall production of some hundred thousand of these post-larvae.

The production of bivalve mollusc seed (Breber, 1985) is still at the experimental stage.

Stocking experiments were made for P. japonicus post-larvae in the lagoon of Lesina with interesting results (Lumare et al., 1984). After initial doubts on the part of traditional producers, an increasing number of extensive stocking experiments are being carried out with hatchery-produced seed of sea bream. Research comparing sea bream seed produced in hatcheries and naturally collected seed have been carried out (Barbaro et al., 1984).

If we consider present seed productive capacity and the demand from valli aquaculture alone, we realize that, for the time being, artificial reproduction obtained with various technologies cannot directly contribute to rearing management of the lagoons.

However more and more experiments are being made with hatchery seed in coastal lagoon aquaculture and it is likely that also in this case North Adriatic aquaculture practised in controlled environments such as the valli will

have the function of perfecting models applicable to lagoon environments.

The seed production itself, its scarcity in nature and the conflicts with small coastal fishing that can be created by fry collecting, are aspects of the same limiting factor that slow down the introduction of improved management in lagoon environments.

10.2 Integrated aquaculture

As already indicated, modern aquaculture of marine fish species in Italy is developing in lagoon areas where tradition and available land suitable to this type of development are present.

In particular in the Upper Adriatic, the concept of integrated aquaculture was developed on the criterion of creating intensive units in the valle areas.

Intensive plants are mainly concerned with eels, sea bass and more recently sea bream. For an analysis of the technologies applied, the reader is referred to the work of Ghittino (1983).

The principle of integrated plants is that of re-using the flowing waters from intensive to extensive or semi-intensive, both to reduce electricity costs for pumping, and to utilize the residual trophic energy (Ravagnan, 1978; 1981).

It was also on this principle that plants were developed also in other parts of Italy and that, according to the availability of land, they developed a higher or lower degree of integration (Fig. 27).

At present, these technologies are in the course of definition also because the management of the fertilized effluents of intensive plants is not easy, especially in relation to the development of impressive biomass of seaweed (i.e., Ulva, Enteromorpha, etc.) when operating with salinities close to that of seawater.

Within the lagoon and valle system, another limit to the development of integrated activities is the quality of the waters, because it is often necessary to use waters without the qualities required for the correct management of intensive plants.

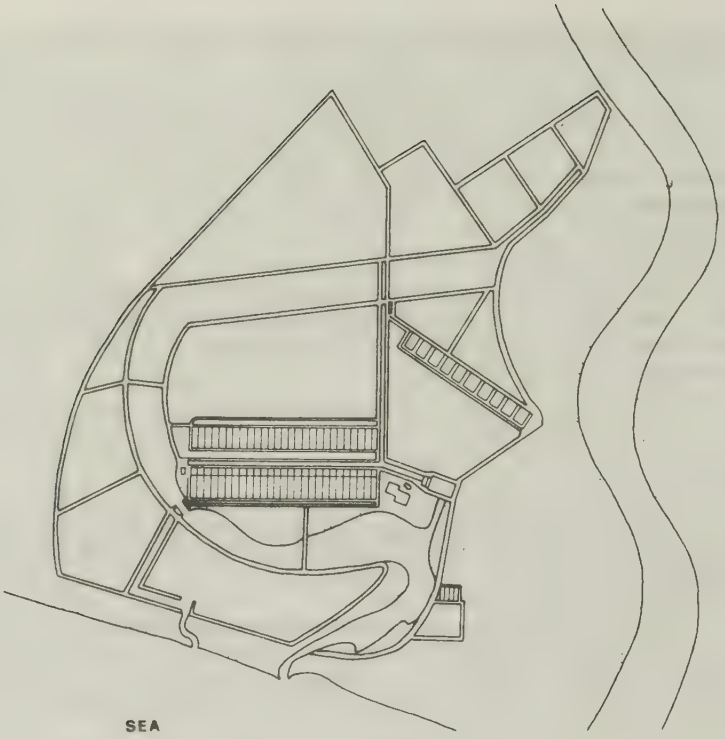

Figure 28. An integrated aquaculture plant in southern Italy.

Of greater interest as management models of lagoon environments are semi-intensive rearings established in lagoon areas. These approaches prompt the consideration that, with sufficient availability of hatchery seed, the lagoon itself might be run, in the future, as a very light semi-intensive plant (Ardizzone, 1984).

Rearing experiments with brackish water earth ponds of various dimensions (from 1,000 m to 5-10 ha) have been carried out in recent years. For example, experiments have been made with fish undersized for the market caught at the fish barriers and reared in ponds. In these basins the diet was based on fresh fish and mixed foods. Sea bream of 140 g reached commercial size averaging around 400 g in about 12 months, with an 86 % survival percentage (Cataudella and Ferlin, 1984).

Other semi-intensive rearing experiments significant for the running of lagoon environments concern the Penaeus japonicus. Besides the mentioned seeding experiments in the lagoons, many trials are being conducted in Italy aimed at the production of these shrimps in earth ponds.

The easiness with which the seed of P.japonicus can be obtained is encouraging many operators to rear this species in eutrophized earth ponds. The average production is around 250 kg/ha/yr, with an average seeding of two post-larvae P.22-P.30 per square metre, obtaining in monoculture a survival percentage of 70%, and in association with other species, around 20% (Lumare et al., 1986).

At present, after the first phase based on the eutrophication of ponds, the tendency is to supplement the feeding with artificial diets.

Semi-intensive rearing experiments have been carried out also for grey mullet, using limited areas of valle environments (Cataudella and Monaco, 1984).

In general, the development of semi-intensive rearing seems promising in the field of research of management strategies for coastal lagoons, and once some limiting factors such as seed availability and conflicts in land utilization area are overcome, this could be the future fish exploitation trend in such environments.

11. CONCLUSION

The Italian experience in the management of coastal lagoons for fisheries and aquaculture is an interesting reference model, probably the most diversified in the Mediterranean region. Thus, it may be useful to draw examples at technical and administrative level, above all in those developing countries, particularly in the Mediterranean area, which request interventions to fill the growing need for fish products. The productive activities in Italian lagoons, and above all in the valli, may indicate management strategies that can provide yields of qualitative and quantitative importance, without necessarily requiring large investments for unit of surface managed.

In the careful analysis of the various forms of intensive aquaculture, in which the limits of an approach requiring heavy investments, substantial energy resources and qualified staff are shown, the lagoon zones are looked at with growing attention.

In the specific case of the Italian experience, the following points synthetically describe the relevant components:

i) The management of the Italian coastal lagoon areas has mainly been based upon fisheries with nets and capture with reed-made fish barriers during the migratory phase. The fish barriers, even in the simplest designs, have always been intended for the capture of eel, even if, for this type of fishing, the use of fyke nets has much older roots.

ii) Even from the pre-Roman age, the concept of hydraulic control has been associated with that of lagoon fishing management, and to this purpose it is enough to recall the hydraulic works in the Latium coastal lakes or in the Orbetello lagoon.

iii) The implementation of lagoon areas delimited by palisades or earth enbankments marked the birth of the valle, successively turned into a true form of aquaculture with hydraulic control, which permits the regulation of continental and marine water flows from which migrations and the lagoon life depend. A selective fish barrier (lavoriero) with functional units for single species has marked a true step forward for valle aquaculture and in general for lagoon management along the Italian coasts. This selective fishing has allowed the exploitation of productive capabilities orienting the catch of the most valuable species toward commercial sizes.

iv) The possibility of catching juveniles of the economically most valuable species near the outlets and the shorelines has made it possible to satisfy the demand for fry of the valli, which have oriented themselves toward the more interesting species which are best fitted to the environmental conditions.

v) The reclamation policy of restoring malarial districts and of recovering areas for agriculture has often reduced the extension of the areas fitted for aquaculture, as in the case of the Comacchio reclamation programme. The development of agriculture, industry, urban and tourist areas along the coastline has had a negative impact upon the lagoon management, creating serious conflicts. Attempts are now being made to solve these conflicts within a picture of environmental conservation where aquaculture must be considered a recovery instrument.

vi) The alterations in the quality of the continental waters have limited, starting in the 1960s, the correct management of the valli and lagoons, particularly in the more developed areas.

The uncontrolled development of human settlements and industrial activities near the lagoon areas and the relevant pouring of polluted waters into the lagoons have created wide phenomena of eutrophication which in turn have caused seasonal distrophies, and in any case modifications of environmental qualities whose effects on the biotic community have been immediate. The present policy of environmental conservation requires expensive interventions to reduce those negative impacts.

The decrease in fry catching has contributed to the search for new development paths. To this purpose many efforts have been made to set up new techniques for the reproduction of sea species and to bring the productive cycles under human control without total dependence on the environmental conditions. The need to increase the productive capabilities per unit of surface, both to respond to the growing market demand as well as to justify in economic terms the increasing costs for manpower tied to the overall socioeconomic growth, has induced the creation of intensive fish farming in valli and lagoon areas.

From this analysis of the Italian experience, the following general recommendations may be drawn, above all directed to those responsible for taking decisions at technical, administrative and political level:

i) Coastal lagoons constitute ecosystems with peculiar productive characteristics whose potential resources, generally of high economic value, may be exploited and transformed with modest means. Therefore, lagoons must be protected and managed as a national resource of primary interest, especially where the food deficits call for serious political commitment tending to the rational exploitation of all renewable resources.

ii) The lagoon, or a part of it, properly delimited as in the case of the Italian valli, represents a true "aquaculture farm" preset by nature in which it is possible to seed, increase productivity and supply food as any practice of aquaculture requires.

iii) It has been found that the best productive strategies in coastal lagoons are those based upon optimization of the ecological characteristics of the systemn: for instance, a

correct hydraulic management guarantees a correct supply of nourishment, a rich migration of juveniles from the sea (where this resource still exists), a possibility of seasonal catch during the migratory phase. Intensive fish farming utilizing lagoon surfaces and lagoon water has not given good results. In this case, the selection of an autonomous site instead of a body of lagoon water is better.

iv) From the viewpoint of resource management, all the methods of highly selective capture for commercial sizes have to be magnified: in this case the Italian lavoriero is one of the most advanced models of fish barrier. The non-commercial sizes of the valuable species may also be routed toward cages or intensive fish farming points, so creating other opportunities of income for the lagoon while exploiting a collective resource.

v) The problem of lagoon management must be approached as a complex part of environmental management in which all the components of an environmental character have to be analysed in physical, biological, economic, social and cultural terms. Only a correct collocation that accounts for the other components and the conflicts among the potential users of the lagoon, fisheries and aquaculture may find a just collocation.

vi) Italian experience teaches that where the various components of the lagoon reality are not accounted for, fisheries and aquaculture have been the most penalized sector, just because they are directly dependent upon environmental quality. Fisheries and aquaculture are even instruments of environmental conservation: the fishermen are in fact supervisors and permanent witnesses of the environmental status, because their income depends upon it.

vii) Finally the evolution of Italian aquaculture shows that it is possible to implement projects that, starting from traditional lagoon management, can develop production strategies based on ever more complex biotechnologies.

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